UNIVERSIDAD COMPLUTENSE DE MADRID

FACULTAD DE CIENCIAS ECONÓMICAS Y EMPRESARIALES

Departamento de Fundamentos del Análisis Económico II (Economía Cuantitativa)

TESIS DOCTORAL

Tres ensayos sobre crédito, liquidez y capital bancario

Three essays on lending, liquidity and bank capital

MEMORIA PARA OPTAR AL GRADO DE DOCTOR

PRESENTADA POR

Álvaro Santos Moreno

Directora

Isabel Catalina Figuerola-Ferreti Garrigues

Madrid, 2016

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Álvaro Santos Moreno

Bajo la dirección de la doctora
Isabel Figuerola-Ferreti Garrigues

Madrid, 2015

A mi esposa

To my wife

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Abstract

The seminal paper of Miller, 1977, highlighted the role of liquidity for price determination. Since then, several studies have tried to explain the determinants of liquidity, and to formalize the implications of that for decision making process of agents. Concerns on the market role of liquidity are, however, not as new as one could think. Two examples, on the importance of liquidity for the determination of asset prices and on how liquidity and capital are related, are the Florentinian banking crisis in the 14th century and the burst of tulips market in the 17th century.

The first banking system, considered to work under modern standards, was born in Florence. Florentinian banks were highly international, family owned, institutions centered on commercial credit and cash management business. The default of the English Crown around 1340, triggered bankruptcy of international business based Florentinian banks. Domestic business based banks, responded reducing the amount of credit to the real economy, to insure cash holdings, while selling Florentinian Republic Bonds. High liquidity of those assets granted, initially, a quick recovery of their investments. However, excess supply of bonds in the market, led to an abrupt price fall. Regulatory response was, then, to buy bonds in the market, in a try to guarantee system stability. Despite those efforts, the entire banking system collapsed and the economic downturn lasted for more than 40 years. Familiar, isn't it?

Another good example, of how capital constraints and liquidity interact, was the burst of tulips market in 1636. Absence of buyers on a routine tulip auction, in Haarlem, triggered price falls. Those plummeted due to short selling activities, and the try to recover cash holdings, by merchants. Merchants have, heavily, invested on tulips following previous years skyrocketing prices. While short selling activities were banned from the market, prices continued falling. Bankruptcy of merchants,

then, lead to the collapse of banking institutions that have lent money using tulips as collateral and despite efforts to sell other assets.

A crucial question is, then, what determines liquidity? My perception is that capital constraints of levered investors essentially determine market liquidity. When a minor capital shock takes place, those agents react by re-balancing their portfolios. If a significant number of investors are shocked, aggregate capital holdings fall below desired levels. This triggers asset sales and price falls. The process spirals until funding needs and capital holdings equate.

The goal of this dissertation is to analyze the interactions between liquidity and capital. This objective in mind, the first and third chapter constitute empirical exercises, that explore the linkages of funding needs, liquidity and price formation on different markets. The first chapter focus on the determination of liquidity formation on Spanish equity markets, while the third analyzes the determination of government bond liquidity for a sample of European countries, the interactions of liquidity across countries and its effects on other markets.

Findings in the first chapter, reinforcing my perception of the crucial role played by capital for the determination of equity liquidity, lead to the formulation of a bank capital determination model. That is presented in the second chapter. The underlying assumption is that a similar relation, to that linking equity liquidity and funding needs, will be present in the determination of liquidity conditions on other markets. High degree of bancarization, then, would lead to put the focus on how banks determine capital holdings, funding needs of the economy and bank capital intimately related.

The determination of liquidity on equity markets will be closely related to developments in the market for borrowing stocks. The prohibition of naked short selling operations, underlie this relation. Agents holding no stocks, but perceiving equity price overvaluation, have to borrow stocks from holders, to be sold in the market. Funding constraints play a crucial role in this process, due to collateral posting. Those have been found relevant, for the determination of asset prices, in the limits to arbitrage literature. Constraints will lead to the violation of the fundamental theorems of finance, preventing agents to exploit profitable investment opportunities.

The relation between borrowing and equity markets, for the Spanish case, is the objective of the first chapter of this dissertation. The effects, of legal constraints to short selling, are also analyzed. An innovative aspect of this study is the use of two differenciated, and exhaustive, datasets, that independently characterize Spanish market for borrowing stocks. Official records from CNMV, on short selling volumes, along with borrowing fees and supplied volumes from International DataExplorers are, simultaneously, used to determine supply and demand equations. The econometric model, there proposed, makes use of an instrumental variables, simultaneous equations, approach. Another differencial aspect is the independent characterization of shifts, on demand and supply patterns. Those are seen to relate with changes either on future stock performance, or on funding needs. Its predictive capacity, on stock returns, is also tested.

The results show that, opposite to the widespread view that blame short selling activities as speculative practices, responsible of market crashes, short selling is a trend chasing behaviour that guarantees price efficiency. Shocking findings relate to the absence of impact of borrowing demand patterns, while supply side shifts are found relevant for the prediction of future stocks performance. That post evidence on the strong impact of financial institutions funding needs for the determination of stock prices.

I, also, find adverse effects arising from short selling regulation. Banning short selling increase the relevance of the borrowing market, stock returns volatility and reduce price efficiency. A regulatory recommendation is, then, to impulse new laws aimed to reduce the discretion present in borrowing activities as opposed to laws that restrict shorting activity.

The close relation between borrowing supply and funding needs, lead me to propose a theoretical model that explain capital decision of banks. Under that model, welfare effects arising from actions in credit markets of monetary authorities are analyzed, too. The novelty of the model relates to its generality, and to the how capital buffers are justified. While existing models found capital on excess of regulation (buffers) to arise from ad hoc imposed frictions, my model points towards its relation with those arise endogenously as a precaution against potential dilution, bankruptcy and to guarantee access to arbitrage opportunities.

My results suggest that arbitrage opportunities, between credit and equity markets, arise simultaneously to the determination of optimal capital levels, granting a proper remmuneration of banking activities. Therefore, capital will optimally be scarce and result in the collapse of credit markets, if arbitrage is present. Welfare results suggest that arbitrage between equity and loan markets is not desirable, leads to increases on moral hazard problems, faced by bank managers and, hence, to increases in deposit insurance costs. A conclusion of the model, then, relates to the necessity of articulate direct banking recapitalization mechanisms.

The relation between capital and bond prices is also analyzed. Bonds are regulatory capital free securities, but default risk leads to the existence of an exponential relation its prices and capital holdings. Further results suggests that bond purchase programmes, like the ones already in place, will have positive welfare effects. Loan acquisitions would be irrelevant, from a welfare perspective, when capital is scarce.

In the third chapter, the exponential relation between bond prices and capital, theoretically posted in the second chapter, is explored. To this end the affine bond price specification presented in Fontaine and Garcia, 2012 is applied for a sample of European countries. The accumulative nature of capital holdings, leads to justify the time a bond has been quoted in the market, as a valid instrument of aggregate economy capital. The affine model is, then, estimated making use of the Unscented Kalman Filter method at a country level. Contangion paterns among European countries are explored using the standardized version of the liquidity factor loading. That measure, also used to characterize the relation of bond liquidity with bank capital formation, CDS spread evolution and cash markets.

The novelty of the study relates, first, with the methodology used to devise liquidity conditions, to the exhaustive set of countries analyzed and, finally, to the use of that magnitude to characterize the existence of liquidity contangion patterns. Novel is, as well, the interpretation of time since issuance variable as an instrument of aggregate capital, while evidence in favour of the validity of that interpretation is also posted.

My results suggest the existence of two liquidity differenciated bond markets within the Eurozone. Those map the traditional Core-Peripherals characterization. An additional differenced behaviour, justified in terms of bond market size, is also found.

However, differenciation is not circunscribed to the evolution of liquidity but also found on the relation between bond and cash markets. While bond and cash markets are sustitutives for Core countries, that is not the case for Peripherals.

Positive evidence on the close relation between liquidity conditions and bank capital, is also found. Liquidity improvements are found to be negatively related, and to predict, the evolution of bank's market-to-book value ratio.

Finally, the commonly accepted leading-lagging relation between CDS spread and liquidity is challenged. I find changes on liquidity to predict departures of credit spreads from their average. I suspect traditional proxies for liquidity, like bid-ask spreads, are highly affected by a measurement error problem, while the mathematical formula for the computation of CDS spreads mechanically transfers bond liquidity variations into those. This results on a higher variation of CDS spreads, when a liquidity shock takes place. That drives the relation found with liquidity proxies. Exploring the existence of such effects, on a longer time span, and for an increased number of countries, will constitute the base of further work.

Resumen

El articulo de Miller, 1977, destacó el papel de la liquidez para la determinación de los precios. Desde entonces, varios estudios han tratado de explicar los determinantes de la liquidez, y de formalizar sus implicaciones para la toma de decisiones de los agentes. La preocupación sobre el papel de la liquidez no es algo tan nuevo como se podría pensar. Dos ejemplos, sobre la importancia de la liquidez para la determinación de los precios y sobre cómo la liquidez y el capital estan relacionados, son la crisis de los bancos florentinos del siglo XIV y el colapso del mercado de los tulipanes en el siglo XVII.

El primer sistema bancario que funcionaba bajo criterios modernos, nació en Florencia. Los bancos florentinos eran entidades familiares, altamente internacionales, cuyo negocio se centraba en los préstamos comerciales y la gestión de efectivo. El impago de la corona británica alrededor del año 1340, llevó a la bancarrota de los bancos florentinos más internacionales. Los bancos domésticos, a fin de garantizar la tenencia de efectivo, respondieron redujendo el flujo de crédito a la economía real y vendiendo bonos de la República. La elevada liquidez de dichos activos garantizaba, en principio, una rápida recuperación del dinero invertido. A pesar de ello, el exceso de oferta de bonos en el mercado, provocó una caída abrupta de los precios. Las autoridades, para intentar garantizar la estabilidad del sistema, reaccionaron mediante la compra de bonos en el mercado. A pesar de lo cuál, el sistema bancario colapsó, y la crisis económica se extendió durante 40 años. Familiar, ¿ verdad ?.

Otro buen ejemplo, de cómo las restricciones de capital y la liquidez interactúan, fue el estallido de la burbuja del mercado de los tulipanes del año 1636. La ausencia de compradores en una subasta rutinaria de tulipanes, en Harleem, propicio la caida de los precios. Estos cayeron, a plomo, como consecuencia tanto de las ventas en corto, como de las ventas de los mercaderes, que intentaban recuperar los niveles de

efectivo. Los mecaderes habían invertido, fuertemente, en dicho mercado los años anteriores por el imparable incremento de los precios. A pesar de la prohibición de las ventas en corto, los precios continuaron su caída. La bancarrota de los mercaderes llevó, a pesar de los intentos por vender otros activos, a la quiebra de las instituciones bancarias que habían prestado dinero respaldado con tulipanes.

Una pregunta crucial es, por lo tanto, ¿cuáles son los determinantes de la liquidez?. Mi percepción es que la liquidez en el mercado viene determinada por las restricciones de capital de los inversores. Cuando el capital se ve afectado por una pequeña perturbación, los inversores reaccionan rebalanceando sus carteras de activos. Si un número significativo de estos inversores se ven afectados, las tenencias agregadas de capital en la economía caen por debajo de los niveles deseados. Eso lleva a ventas de activos y caídas de precios. El proceso se retro-alimenta, hasta que las tenencias de capital y las necesidades de financiación se igualan.

El objetivo de este documento es analizar las interacciones entre el capital y la liquidez. Con este objetivo en mente, el primer y el tercer capítulo constituyen ejercicios empíricos, que exploran los lazos entre las necesidades de financiación, la liquidez y la formación de los precios, en diferentes mercados. El primer capítulo se centra en la determinación de la liquidez en el mercado de acciones de España, mientras que el tercero analiza la determinacion de la liquidez en el mercado de bonos, para una muestra de países europeos, las interacciones de ésta entre países y sus efectos en otros mercados.

Los resultados del primer capítulo, que refuerzan mi percepción del papel crucial que juega el capital para la determinación de la liquidez de los activos, me lleva a formular un modelo para la determinación del capital óptimo bancario. Este modelo se presenta en el segundo capítulo. El supuesto subyacente a este modelo es que una relación similar, a la observada entre la liquidez en el mercado de acciones y las necesidades de financiación, debería estar presente en la determinación de las condiciones de liquidez en otros mercados. El alto grado de bancarización de la economía me lleva a poner el foco en cómo los bancos determinan los niveles de capital.

La liquidez en los mercados de acciones está íntimamente relacionada con la evolución del mercado de prestamo de acciones. La prohibición de las ventas en corto descubiertas subyace dicha relación. Los inversores sin acciones, que perciben sobrevaloración en el precio de las mismas, han que pedir prestados títulos para realizar ventas en el mercado. El posteo de colaterales lleva a que las restricciones de financiación jueguen un papel crucial. La relevancia de dichas restricciones, para la determinación de los precios de los activos, ha sido ilustrada en la literatura sobre los límites al arbitraje. Dichas restricciones llevan a la violación de los teoremas fundamentales de las finanzas, impidiendo que los agentes económicos exploten oportunidades de inversión beneficiosas.

La relación entre los mercados de préstamo y de acciones, para el caso español, es el objetivo del primer capítulo de esta disertación. En él, también se analizan los efectos de las restricciones legales a las ventas en corto. Un aspecto novedoso del estudio es el uso de dos bases de datos diferenciadas, y exhaustivas, que independientemente caracterizan el mercado español de préstamo de títulos. Los registros oficiales de la CNMV, sobre volúmenes de ventas en corto, y las comisiones y oferta de acciones en préstamo, provenientes de International DataExplorers, son utilizadas, simultáneamente, para determinar las ecuaciones de oferta y demanda. Dichas ecuaciones son estimadas utilizando un enfoque econométrico de variables instrumentales y ecuaciones simultáneas. La caracterización independiente de los cambios en las pautas de oferta y demanda, constituye otro aspecto diferencial. Estos estan relacionados o bien con cambios en la percepcion del comportamiento futuro de las acciones o de las necesidades de financiación. Su capacidad predictiva, sobre la rentabilidad de las acciones, también se analiza.

Contrariamente a la visión que considera las actividades de ventas en corto como prácticas especulativas, responsables del colapso de los mercados, éstas constituyen un comportamiento de seguimiento de tendencia que garantiza la eficiencia de los precios. Interesantes resultados surgen de la ausencia de impacto de las pautas de demanda de títulos en préstamo, mientras que los cambios en las pautas de oferta predicen el comportamiento futuro de las acciones. El impacto de las necesidades de financiación para la determinación de los precios queda claro. Prohibir las ventas en corto incrementa la relevancia del mercado de préstamo, y la volatilidad de la rentabilidad de las acciones, mientras que reduce la eficiencia de los precios. Se habrían de impulsar, pues, nuevas leyes encaminadas a reducir la discrecionalidad presente en dichas actividades y no a restringir las ventas en corto.

La íntima relación entre la oferta de préstamo de valores y las necesidades de financiación, me lleva a proponer un modelo teórico que explique las decisiones de capital de los bancos. Bajo ese modelo, los efectos en términos de bienestar social que surgen de las acciones de las autoridades monetarias en los mercados de crédito también se analizan. La novedad del modelo propuesto radica en su generalidad, y en cómo se justifican los colchones de capital. En los modelos existentes, el exceso de capital sobre el regulatorio (colchón) surgen de la imposición ad hoc de fricciones. Mi modelo sugiere que estos surgen endógenamente como protección contra una potencial dilución, la bancarrota y para garantizar el acceso a oportunidades futuras de arbitraje.

Las oportunidades de arbitraje, entre el mercado de acciones y el secundario de crédito, surgen simultáneamente a la determinación de los niveles óptimos de capital bancario, garantizando una apropiada remuneración de las actividades bancarias. El capital será óptimamente escaso lo que, en presencia de arbitraje, lleva al colapso del crédito. Los resultados sobre bienestar social sugieren lo indeseable del arbitraje entre los mercados de acciones y crédito. Éste lleva a incrementos en los problemas de riesgo moral afrontados por los gestores bancarios, y a incrementos en los costes ligados al aseguramiento de los depósitos. Una conclusión es, pués, la necesidad de articular mecanismos directos de recapitalización bancaria.

La relación teórica entre el capital y el precio de los bonos, tambien es analizada. Aunque los bonos son activos no sujetos a regulación en términos de capital, el riesgo de impago lleva a la existencia de una relación exponencial entre precio y capital. En términos de bienestar social, las compras de bonos producen incrementos mientras que, cuándo el capital es escaso, las adquisiciones de préstamos son irrelevantes.

En el tercer capítulo, la relación exponencial entre los precios de los bonos y el capital, sugerida teóricamente en el capítulo anterior, es explorada. El modelo afín para el precio de los bonos presentado en Fontaine y Garcia, 2012, es aplicado a una muestra de países europeos y estimado mediante el método del Filtro de Kalman “Unscented”. La naturaleza acumulativa de los niveles de capital, justifica la utilización del tiempo transcurrido desde la fecha inicial de emision de un bono, como un instrumento válido del capital agregado de la economía. Las pautas de contagio en liquidez entre los páises europeos son exploradas mediante la utilización del coeficiente estandarizado ligado a nuestra variable exponencial. Esa variable, tambien es utilizada para caracterizar la relación entre la liquidez de los bonos y la formación de capital bancario, así como con la evolución del "spread" de los CDS y los mercados de efectivo.

La novedad del estudio esta relacionada, en primer lugar, con la metodología aplicada para recuperar las condiciones de liquidez, con la extensión de los paises analizados y, finalmente, con el uso de dicha magnitud para caracterizar las pautas de contagio en liquidez. Novedosa es, así mismo, la interpretación del tiempo transcurrido desde la emisión de un bono como un instrumento del capital agregado, al mismo tiempo que la evidencia en favor de dicha interpretación mostrada.

Mis resultados sugieren la existencia de dos mercados de bonos, diferenciados en términos de liquidez, en la Eurozona. Esos se corresponden con el tradicional mapeo en términos de paises nucleares y periféricos. También se encuentra un comportamiento diferencial adicional, que puede ser justificado en términos del tamaño del mercado de bonos. Dicha diferenciación no se circunscribe, únicamente, a la evolución de la liquidez, sino también a la relación de esta con los mercados de efectivo. Mientras que el mercado de bonos y de efectivo son sustitutivos para los países nucleares, éste no es el caso para los periféricos.

Tambien se encuentra, en este capítulo, evidencia en favor de la íntima relación entre liquidez y capital bancario. Las mejoras en la liquidez estan negativamente relacionadas, y predicen, la evolucion del ratio de valor de mercado sobre valor en libros de los bancos.

Finalmente este estudio contradice la, aceptada, naturaleza adelantada de los cambios en el "spread" de los CDS frente a la liquidez. Mis resultados indican que los cambios en la liquidez predicen las desviaciones de los "spreads" de sus valores medios. Sospecho que los proxies tradicionales para la liquidez, como el spread oferta-demanda, están afectados por un problema de error de medida, mientras que la fórmula de cálculo del "spread" transfiere, mecánicamente, los cambios en la liquidez a dichos spreads. Esto implica una mayor variación en los "spreads" frente a los proxies, en presencia de perturbaciones de liquidez. Explorar la existencia de dicho error de medida constituye la base para un próximo trabajo.

Chapter 1.

Stock lending, Short Selling and Market Returns: The Spanish Market

Abstract

In this chapter, the relation between the market for borrowing stocks and stock price evolution, for the Spanish case, is illustrated. My findings points towards the existence of an asymmetric relation between borrowing activities and stock prices. In line with a trend chasing behavior of short sellers, borrowing costs are relevant when stocks underperform the market. Supply side “endogenous” borrowing restrictions, likely to arise due to funding and capital constraints, are found relevant to understand future evolution of stock market. Unpredicted changes on demand patterns will not be affecting that evolution. This is in contrast with the extended view of short selling as price manipulation activities. The relation between borrowing market and bubbles conformation, in the short and the long run, is also analyzed. Borrowing activities help to keep price expectations and intrinsic firm value aligned, in the short run, while in the long run both measures converge. The effect of legal restrictions to short selling, like the one imposed by CNMV on September 22nd 2008, is also analyzed. The introduction of new regulation has not reduced the pricing impact of short selling activities. New regulation has reinforced market power of stock lenders, hence increasing the effect of borrowing activities on stock performance.

Resumen

En este capítulo, se ilustra la relación entre el mercado de préstamo de acciones y la evolución de los precios, de las mismas, para el caso español. Mis resultados sugieren la existencia de una relación asimétrica entre las actividades de préstamo de títulos y el precio de la acciones. En línea con un comportamiento de seguimiento de tendencia, por parte de los vendedores en corto, cuando las acciones se comportan peor que el mercado los costes asociados a la actividad de préstamo son relevantes. Las restricciones endogenas de oferta de títulos en préstamo, que surgen como resultado de restricciones de fondeo y capital, son también relevantes para entender la evolución futura del mercado de acciones. Cambios no previstos en las pautas de demanda no afectan a esta evolución. Esto contradice la visión, ampliamente extendida, que entiende la actividad de ventas en corto como manipulación de precios. La relación entre el mercado de préstamo y la formación de burbujas en el mercado, en el corto y el largo plazo, tambien es analizada. La actividad de prestamo de títulos ayuda a mantener alineadas las expectativas de precios y el valor intrinseco de las compañias cotizadas, en el corto plazo, mientras que en el largo plazo ambas convergen. El efecto de las restricciones legales a las ventas en corto, como la impuesta por la CNMV el 22 de Septiembre de 2008, también se analizan. La introducción de nueva regulación no ha reducido el impacto en los precios de las actividades de ventas en corto. La nueva regulación ha incrementado el poder de mercado de los prestamistas de títulos, de este modo incrementado el efecto de las actividades de prestamo en el comportamiento de las acciones.

1.1. Introduction

In recent years a discussion on the effects of short selling for stock performance took place. The mainstream of thinking blame short sellers of fatal market crashes, identifying short selling activities with price manipulation. This opinion is not new. It was in Netherlands, in 1680, when the first short selling restriction was imposed. Short selling practices were blamed for the crash in tulips market, and those activities forbid. However, the empirical evidence on the effects of short selling practices is mixed.

After the fall of Bearn & Stearns, in March 2008, and the stock exchange crash, regulators across the world limited short selling activities in the market. The 22nd of September 2008, Spanish Stocks Exchange Regulator, CNMV therein, published a regulatory note reminding the prohibition of "naked" short selling operations, and the obligation of short sellers to disclose their positions when those exceed the 0.25% of company's free float. The effects of that regulation, on market performance, have not been analyzed, so far. This study pursues a double objective: to analyze the determinants of stock borrowing decision, and to characterize the relations between the market for borrowing stocks and stock market.

My findings post evidence on the relevance of borrowing activities to increase market liquidity. Theoretical and regulatory linkages between stock borrowing and short selling activity allow an interpretation, of my results, in terms of short selling behavior. Short selling (stock lending) present a non monotonic relation with contemporaneous company returns. When a stock performs better than the market, short selling activity has no relation with performance while bad performance is reinforced by borrowing activities. This should be understood as the outcome of limited rationality (trend chasing) and overreaction of stock markets.

Evidence of a negative relation between lending activity and future stock returns is, also, found. That relation is driven by restrictions in borrowing supply rather than in demand, and reflects the existence of a supply monopoly, outcome of funding and capital constraints.

I, also, find a negative relation between short term market bubbles and constraints to borrowing activities for highly capitalized companies. That is related to the liquidity role of short selling activities.[1] On the other hand, long term market performance and lending constraints are not related. Hence, in the long run, negative information is impounded in market prices independently of market liquidity, while lending constraints affect the speed at which information is reflected in market prices.

Market capitalization is relevant to understand the relation between stock and lending markets. Highly capitalized companies are more sensible to borrowing restrictions than small capitalized firms. This highlights the prevalent role of liquidity to determine investment decisions.

Regulation enforced by the CNMV, on September, has tightened the link between stock and lending market, increasing the market power of stock lenders and reinforcing above described relations.

My results are of special relevance for regulators and practitioners, and post evidence in favor of the positive price efficiency effects of short selling activity. Short selling regulation will translate on restrictions affecting the lending market, increases in funding costs and reductions of price representativity.

The structure of this chapter is as follows: in the next section I explain what a simple shorting operation looks like and the mechanics of shorting in Spain. In section 3 a brief review of existing literature is presented. Section 4, presents the data used in this study. In section 5, supply and demand for lending are characterized. In section 6 results on the relation between lending and stock markets are presented while, in section 7, I conclude.

1.2. Short selling

In this section I characterize the players in short selling market, describing the mechanics of short selling for naked and a non-naked operations, further explaining the singularities of short selling activities in Spain. Finally I elaborate on the effect of dividends, recalls and collateral for borrowing activity.

[1] Short selling increases the liquidity of a stock by increasing supply of stocks, which in turn increases trading possibilities of the agents

1.2.1. Players

Stock lenders are custody banks. They lend stocks on behalf of large institutional owners such as pension funds, mutual funds and endowments. Financial intermediaries play a central role as clearinghouse of this operations, dampening seeking costs and noise induced by positions taken by individual money managers.

Security borrowers are an heterogeneous group. Specialists and market makers have obvious shorting needs to balance buy and sell orders. Traders of options are another important group of borrowers while, perhaps, the most important group is composed by Hedge Funds, that use borrowing positions in their "arbitrage" strategies (see Table 1.1).

Table 1.1.: *Relevant Short Selling Positions In Spain*

Company/Date	24-Sep-08	25-Sep-08	29-Sep-08	09-Oct-08
Banco de Sabadell	Calypso Capital Management, Highside Capital Management	Tiger Global Management, Calypso Capital Management		
Bankinter	John A. Griffin, Highside Capital Management			
Banco Popular	Amber Master Fund, John A. Griffin, Harbinger Capital Partners Master Fund I, Lansdowne Global Financials Fund, Highside Capital Management	Tiger Global Management, Viking Global Investors	Fidelity International	
Banco Pastor	Fortelux Capital Management			
BBVA	Harbinger Capital Partners Master Fund I			Harbinger Capital Partners Master Fund I

1.2.2. The mechanics of short selling

To explain the mechanics of short selling operations I consider an example concerning three agents (A, B, C) and one company (D). Agent A is the short seller, agent B is the lender, agent C is a potential stock buyer and D is a traded company. I will distinguish between naked and non-naked operations.

1.2.2.1. Pure Naked shorting operation

A naked short selling operation implies an agent (A, in our simple example) going to the market to sell stocks of a company (D) that she does not already own. There are many reasons to short sell stocks in the market but two emerge as principal. The first one is the existence of some necessity by the agent to hedge a previous operation (e.g. a long position in a convertible bond), whilst the second obeys to purely speculative motives (e.g.information about negative development of the company in the future).

By undertaking this position the agent will earn money whenever the stock falls, as he will be able to close the position buying previously shorted stocks at a lower price. Simultaneously she faces some costs, due to the payment to agent C any dividend the stock pays until the position is hedged.

This style of shorting leads the seller to behave as a market maker, implying an artificial increase in the supply of stocks of the company. Consequently, those activities are forbidden, in most developed countries, as could result on stock price manipulation.[2]

1.2.2.2. Non naked shorting operation

As pure "naked" short selling operations are not allowed in most developed countries, short sellers have to posses stocks before the liquidation date arrives. To do so, the short seller (A) borrow stocks from an investor (say B) already owning them.

[2] If the amount of assets a Short Seller could trade in the market is not limited by the existing mass of issued stocks, agents could reduce the price below its "true" value. This could lead to the creation of arbitrage opportunities.

On exchange for this loan, agent B typically asks for some acceptable collateral (for simplicity cash) which he remunerates to A at an interest rate (rebate rate). As in the case of a naked position, agent A pays to B any dividend until the operation is canceled. Once the loan operation is set, A goes to the market and sells stocks to C.

After some time, agent A buys back stocks in the market, giving them to B, ending the lending operation. The complete result of the operation for agent A will be determined by the difference between payments (rebate plus the difference between selling and buying price) and costs (opportunity cost of the collateral and any dividend payment during the operation)

1.2.2.3. Settlement, liquidation and fail to deliver

On the vast majority of markets in the world, settlement and liquidation happen simultaneously (typically three days after the operation is performed) with trading taking place in advance. Decoupling of trading and liquidation opens room for *de facto "naked short selling"* operations and *fail to deliver*.

De facto *"naked short selling"* follows the gap between liquidation and trading day, and the role of the clearing house as a mere transmitter of stocks. As verification of property just takes place after effective trading, any agent would have enough time to look for stocks to hedge a short selling operation, if at the moment he took this short position he did not own enough stocks. This practice raise moral hazard concerns for custody banks, their payment dependent on the number of Trading Accounts.

Fail to deliver occurs when an agent is unable to locate stocks to deliver in settlement/liquidation date. Such phenomena cancels the trading operation, short seller having to pay a predetermined fee as penalty. *Fail to deliver* causes damage for the buyer, who could find himself in a higher price market to buy stocks.

1.2.3. Short selling in Spain

1.2.3.1. Short selling mechanics in Spain before September 22nd 2008

Let us, now, suppose that agent A, who does not own stocks of company D, sold stocks of that, to agent C, at date t. According to Spanish regulation settlement of the operation will happen at the very moment that the operation happens but liquidation will take place at $t + 3$. It implies that A has 3 days to borrow stocks from another agent (B), who actually owns the stock, in order to hedge his position.

If liquidation date arrives and A's position is not covered, an special mechanism will be initiated, the clearing house (Iberclear) will subtract from A's guarantee account the money obtained from the short selling operation plus a 10% as penalty.

1.2.3.2. Short selling mechanics in Spain after September 22nd 2008

In September 22nd 2008, CNMV imposed regulatory restrictions to short selling. In concrete, from that date on, no agent can sell stocks in the market if at the date of the operation she cannot prove the property of enough stocks or rights on stocks to hedge her operation. From that date on mechanics have simplified very much: Agent A borrows stocks from agent B at date t or before, then agent A sells these stocks to agent C in the market at t. At $t + 3$ liquidation happens.[3]

1.2.3.3. Settlement and liquidation timing in Spanish Market

Under Spanish market laws settlement of the operation takes place in the very moment trade happens, t, and there is no room for *fail to deliver*. The clearing house has to deliver the stocks to C and the operation can not be reversed. In case liquidation date arrives, $t + 3$, and agent A doe not hold enough stocks to cover the operation, the Clearing creates a Registry Note (or *Nota de Registro*). This Registry Note is in fact a temporal issuance of stocks of company D, which will be reversed in the moment Iberclear buys stocks in the market to hedge his position. This implies a temporary increase in the supply of company C stocks.

[3] Liquidation in this context is just the registry of the operation and the exchange of money from one broker's account to another

1.2.3.4. Dividend dates

Taxation on dividends is similar in Spain and in other OECD countries. Dividends are taxed in the moment they are received by the agent with a general tax rate of 21%. As a consequence, lending around dividend dates exhibits a differential behavior translated into an increase in both, supply and demand due to tax shield motives.[4]

Regarding stocks property, Spanish laws claims that the actual owner of the stock is the one who should receive dividend payments. Coming back to our example, when a dividend date arrives, agent A has to pay any dividend to agent B. This implies an increase in the cost "paid" to short stocks in the market.[5]

1.2.3.5. Recalls and collateral

Spanish laws do not differ to US laws on recalls. Any lender has the right to cancel, in any moment, the operation asking for the return of lent stocks. If that happens, short seller need to go to the market and buy back as many stocks as borrowed. On collateral, legislation is not in place. However, CNMV general recommendation is those not to be smaller than 100 percent.

1.3. Literature review

Some studies are of special relevance to understand the importance of short selling, from a theoretical point of view: Miller (1977), Hong and Stein (1999) and Hong, Lim, and Stein (2000), Diamond and Verrecchia (1987) and, more recently, Goldstein and Guembel (2008).

In Miller (1977), the author concludes that, under uncertainty, banning short selling will go against market efficiency, reducing the incorporation of negative information on stock prices. This will lead to a reduction of stock liquidity, to the creation

[4]Suppliers receive dividends from demandants, these dividends are taxed at their marginal rate and they avoid to pay in advance at a bigger rate. The type of borrowers is then modified, with pension and mutual funds interested on dividends, changing their typical role of lenders.

[5]A is paying the Lending Fee+Perceived dividend+Tax of dividend

of bubbles, and to a reduction on the frequency of negative returns and volatility. When prices are high enough, no one is willing to buy stocks, bubbles collapse and a market crash follows. Similar results are found in Hong and Stein (1999) and Hong, Lim, and Stein (2000).

Similar conclusions, now arising from informational asymmetries, are found on Diamond and Verrecchia (1987). Assuming that informed traders receive a perfect signal on firm value, short selling bans will impede informed traders, with negative expectations, to translate their information on prices. This will cause a reduction in market efficiency, volatility and liquidity, while feeding up bubbles.

More recently, Goldstein and Guembel (2008) arrive to opposite conclusions, by means of game theory, under a four date model of heterogeneously informed traders. Opposite to the assumption in Diamond and Verrecchia (1987), the signal perceived by informed traders is not perfect, and beliefs are updated every period by both uninformed and informed agents. Uninformed traders will behave as trend chasers, perceiving price falls as signals of informed traders behavior. Therefore, short selling activities could lead to efficiency losses, prices not reflecting negative information but overreacting to imperfect signals..

Some empirical papers are also relevant: Jones and Lamont (2002), D'Avolio (2002) and Bris, Goetzmann, and Zhu (2007).

Jones and Lamont (2002) analyze the capacity of short selling restrictions to predict future market returns and bubble creation (overpricing hypothesis) for the 1925-1933 period. They conclude that short selling restrictions open room for predictability, on stock returns, and lead to company overvaluation (measured as market to book ratio).

D'Avolio (2002) studies borrowing stocks market, concluding that firm size, institutional ownership and recall probabilities are crucial to understand the supply of lending stocks. He also posts evidence in favor of Miller's assumption: short selling reflects asymmetric beliefs on stock prices. Stock prices and lending supply are positively correlated, falling prices increase recall probabilities: lenders are more tempted to sell stocks to reduce risk. The fall in lending supply will impose an endogenous constraint on short selling, reducing rebate rates and liquidity, while increasing the cost of lending.

Bris, Goetzmann, and Zhu (2007) test for the efficiency (predictability) in stock returns by means of panel regression. Using a legal indicator of short selling restrictions for each considered market, they conclude that short selling restrictions cause market inefficiency, creating room for returns predictability.

My study is close to D'Avolio (2002) and embeds in the not so exhaustive literature on the interactions between the lending and stocks market. Making use of a new database, I analyze the effects of borrowing activity on stock market performance. I find a positive relation between endogenous supply side restrictions on lending, understood as unexpected divergences on borrowed amounts from its long run equilibrium, and abnormal stock returns. Also, opposed to the assumption in Goldstein and Guembel (2008), I find evidence on a trend chasing behavior of borrowers (short sellers) when market prices fall. Hence, short sellers do not seem to behave as informed investors.

1.4. The data

My data is composed of 135 Spanish listed companies during the period between January 2005 and December 2008. It includes lending volumes from CNMV official registries, closing prices, volumes, bid-ask spreads, and specific company data from Thomson Financial Datastream. From this provider I also get data on right issuances and convertibles. This results on 56 rights issuances and two traded convertibles. From individual closing prices, a value weighted index along with its returns are computed. Those are, then, used to obtain abnormal returns for each company, using the CAPM equation.

Additionally, I got daily data on lending fees and total supply of stocks for lending, from International Data Explorers of London. The computation of lending fees depends on the collateral posted. When a loan is cash collateralized, lending fee is computed as the difference between the one day Libor and the rebate rate. Otherwise, the fee is fixed, by the bank, according to internal considerations. Data on fees is aggregated, to a weekly level, using daily lending volumes as weights. However, data on fees is not exhaustive. Lending activity is absent for 32 companies included in our original sample and those are dropped from the final data-set.

In Table 1.2 and Table 1.3, major descriptive statistics for the whole sample, and by market capitalization, are shown. Untabulated correlation tables post evidence on the existence of negative correlation between lending interest[6] and borrowing fees. More borrowing implies bigger rebates and lower fees. However, when controlling for market capitalization, this relation is not so clear. Small capitalized firms (up to 80% of market capitalization) exhibit the typical positive relation, whereas for big companies that relation inverts. Also, a negative relation between costs (fees) and market-to-book values is found. This suggests the existence of overvaluation on stocks subject to higher borrowing constraints.

Table 1.2.: *Descriptive Statistics (Panel A)*

Deciles of Market capitalization	*Number of companies*	*Mean Lending interest (%)*	*Standard deviation of lending interest*	*Weekly Return volatility*	*Mean lending Fee (%)*
Total Sample	*103*	*0.07*	*1.58*	*0.04*	*1.420*
Decile 1	*11.00*	*0.04*	*0.31*	*0.048*	*2.840*
Decile 2	*10.00*	*0.15*	*0.79*	*0.059*	*2.520*
Decile 3	*10.00*	*0.17*	*0.50*	*0.046*	*2.240*
Decile 4	*10.00*	*0.29*	*0.71*	*0.041*	*1.580*
Decile 5	*11.00*	*0.31*	*1.00*	*0.050*	*1.980*
Decile 6	*10.00*	*0.42*	*1.35*	*0.043*	*1.380*
Decile 7	*11.00*	*0.72*	*1.32*	*0.039*	*0.890*
Decile 8	*10.00*	*1.11*	*1.65*	*0.041*	*1.020*
Decile 9	*10.00*	*1.03*	*1.82*	*0.040*	*0.960*
Decile 10	*10.00*	*1.69*	*2.67*	*0.031*	*0.540*

Figure 1.1 illustrates the existing relation between lending fees and lending volumes. On average, lending volumes and fees have increased over the considered period. This could reflect the existence of market overvaluation, resulting on an increase in short selling interest. However, fees have experienced a tight increase from April 2008, following the fall of Bear & Stearns while lending activities have reduced. As funding needs are relevant to understand the interest of stock suppliers on lending, this reflects an increase on funding costs (risk perception) from that date.

Figure 1.2 depicts the relation between lending fees and dividend dates. Clearly,

[6] See sec. A for a description on how this variable is constructed

Table 1.3.: *Descriptive Statistics (Panel B)*

	Abnormal Return>=0			***Abnormal Return<0***		
Deciles of Market capitalization	*Mean Weekly return (%)*	*Mean Lending interest(%)*	*Mean Lending Fee (%)*	*Mean Weekly return (%)*	*Mean Lending interest(%)*	*Mean Lending Fee (%)*
Decile 1	0.032	0.047	2.596	-0.024	0.038	2.649
Decile 2	0.037	0.145	2.496	-0.031	0.155	2.398
Decile 3	0.032	0.165	2.096	-0.027	0.177	2.176
Decile 4	0.032	0.284	1.578	-0.025	0.300	1.527
Decile 5	0.034	0.290	1.831	-0.028	0.321	1.870
Decile 6	0.031	0.386	1.309	-0.026	0.442	1.411
Decile 7	0.029	0.681	0.846	-0.024	0.765	0.937
Decile 8	0.030	1.092	0.883	-0.025	1.133	1.028
Decile 9	0.029	1.021	0.866	-0.024	1.045	1.010
Decile 10	0.021	1.760	0.478	-0.018	1.633	0.617
Total Sample	0.030	0.691	1.297	-0.025	0.671	1.442

tax shield motives drive borrowing decisions around dividend dates. Consequently, dividend payment dates should receive a differential treatment when characterizing the structural relation between stocks performance and the behavior of agents in the lending market.

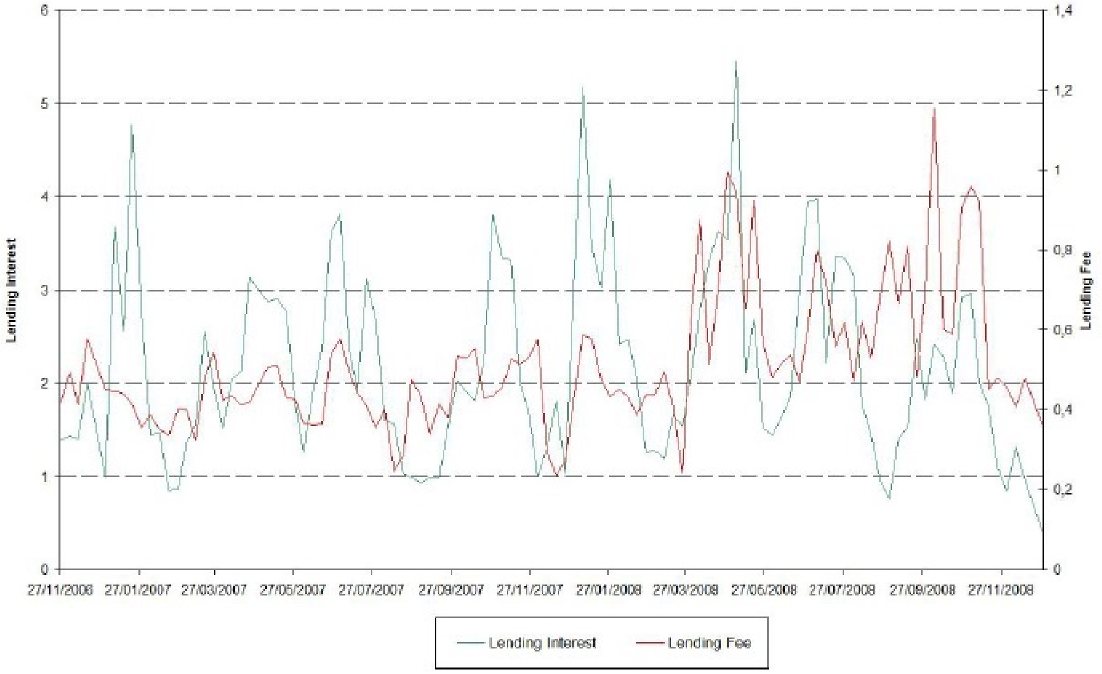
Figure 1.3 plots the evolution of our value-weighted index against the evolution of lending fees. The increase of lending fees, from April 2008, have been paired with a reduction on the index value. However, the graphical illustration is unclear on whether the increase on lending fees is prior to the fall on index value.

In Figure 1.4 the relation between abnormal returns and lending fees is illustrated. An increase of abnormal returns volatility is paired with above average lending fees (and of lending volumes) while the increase in abnormal returns at the end of the sample period, coincides with a fall in lending fees. The tight relation here illustrated emphasizes the importance of lending fees to understand the evolution of stock prices.

1.5. The market for borrowing stocks

Absence of exhaustive databases on lending volumes (I am just aware of the existence of such official records for Spain) has almost totally prevented (see D'Avolio (2002))

Figure 1.1.: *Lending Interest vs Lending Fees*



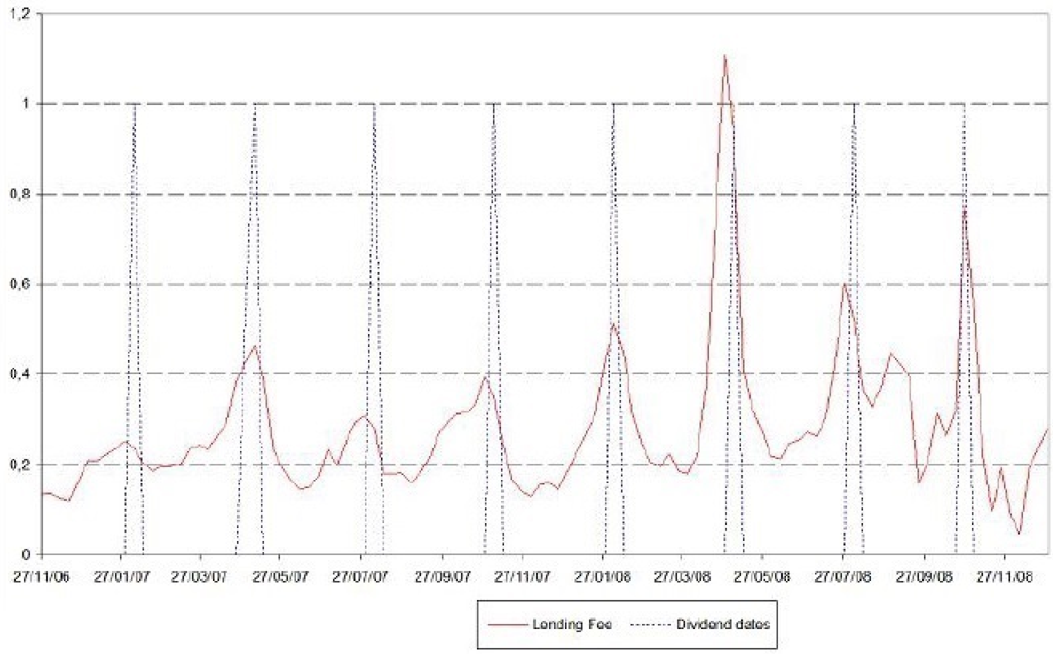
the existence of studies analyzing the relation between borrowing and stock markets. In what follows I propose a market micro-structure approach based on the estimation of borrowing markets supply and demand equations to analyze that interactions.

Estimation of supply and demand equations is problematic. One only observes equilibrium lending volumes and fees, resulting from interactions between supply and demand, then identification of equation based coefficients should rely on an instrumental variables approach.[7]

Why is so important to determine supply and demand equations? One of the biggest findings in Jones and Lamont (2002) is that short selling restrictions predict future abnormal returns. Those short selling restrictions could be the result either of legal restrictions or of market conditions. While regulatory (legal) constraints to short selling could be directly identified, the identification of endogenous constraints to short selling should relate to frictions in stock lending markets.

[7]I use a simultaneous equations approach to avoid the inconsistency of estimators that is present when using single equations model. It also allows us to find plausible instruments to identify the effects of endogenous variables in the model

Figure 1.2.: *Lending Fees and Dividend Dates*



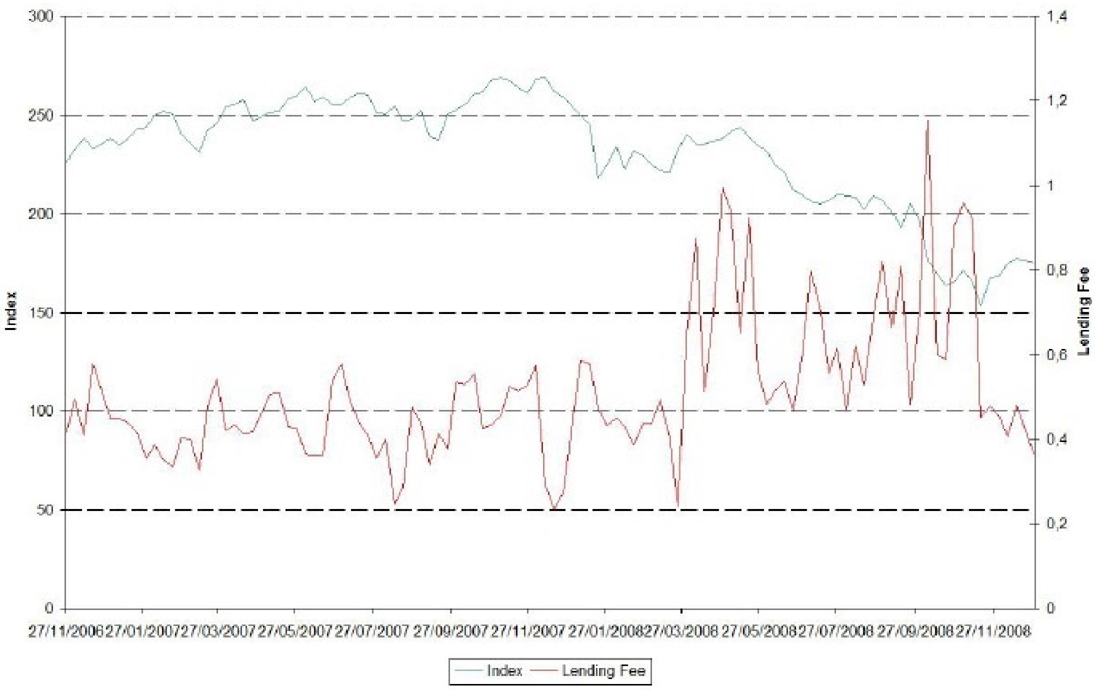
The evolution of supply and demand in the lending market is related to different factors. While stock supply would relate with funding and capital constraints of financial agents,[8] or from company specifics, changes in demand relate to the perception of future evolution of stock prices and, hence, on the existence of informational asymmetries amongst market participants.

In Figure 1.5 an illustration of the theoretical implications of shifts on supply and demand for lending fees is presented.

A negative demand shift will, "ceteris paribus", reduce cost. This shift should arise as a consequence of a reduction in the amount of negative information affecting a company, as perceived by market participants. Then, this reduction will result in a decrease of short selling activities and on higher stock returns. Similarly, a negative shift in supply should correspond to a reduction in funding needs of stock holders,

[8]The reason why funding and capital constraints are related to supply patterns rely on the existence of regulatory capital asymmetries regarding the threatment of stocks incorporated in balance sheets of financial entities subject to regulation, as well as in the characterization of the lending market as the only way to finance equity positions

Figure 1.3.: Index vs Lending Fees



and should also lead to higher returns. Summarizing, predicted effects of shifts are:

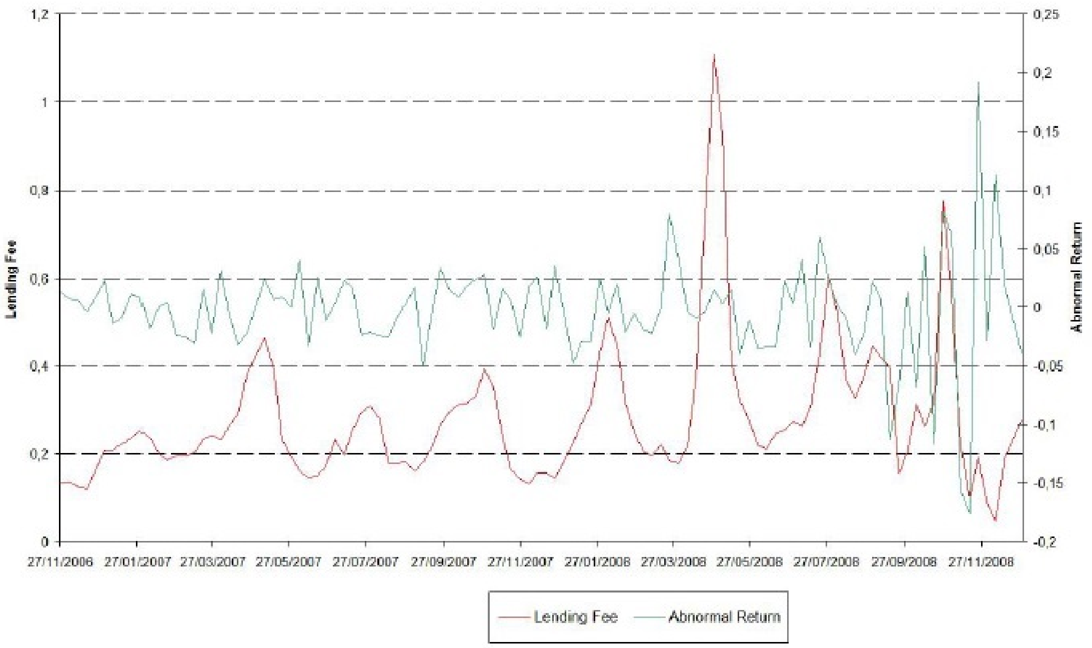
- A positive demand shift will increase cost and lending volume. A higher amount of stocks could be short sell and returns will reduce.
- A positive supply shift reduces costs and increase lending volumes. A higher amount of short positions would follow, reducing stock returns.

1.5.1. Specification of Demand and Supply Equations

To identify borrowing stock supply, I propose the following heuristic equation:

$$S_{it} = c_i + \alpha Cost_{it} + \delta Cost_{it} * CNMV_{it} + \beta S_{it-1} + \omega S_{it-1} * CNMV_{it} + \gamma PctileMK_{it} + \theta CNMV_{it} + u_{it}$$

Figure 1.4.: *Abnormal Returns vs Lending Fee*



while demand equation is:[9]

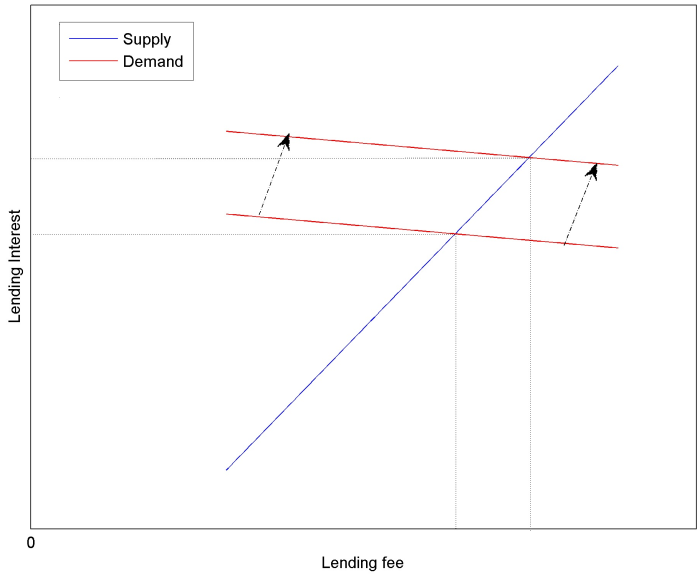
$$D_{it} = \alpha_i + \beta Cost_{it} + \gamma Lend_{it-1} + \omega Dividendo_{it} + \theta Momentum_{it} + \eta Pctlending_{it-1} + \\ + \lambda Cost_{it} * CNMV_{it} + \kappa Lend_{it-1} * CNMV_{it} + v_{it}$$

Funding needs are, essentially, determined by stable variables, opportunity costs and economic situation. A big supply of stocks for lending will be related to strong funding needs, whose determinants would be persistent. Hence, present and past lending supply, S_{it-1}, should be positively related.

The existence of two differentiated market indexes in Spain, facing different liquidity, and with stocks assigned to each one according to market capitalization, underlie the inclusion of a variable characterizing market cap, $PctileMK_{it}$, on supply specification.

[9] On estimation, supply and demand amounts on the left hand side of the equations are characterized via lending interest whose definition could be found in sec. A

Figure 1.5.: *An illustration of a Demand Shift*



The modification of the legal environment, due to new regulation, lead my decision of introducing a dummy variable, $CNMV_{it}$, (and its interactions with cost and past supply) that takes a value of 1 for each week from 22^{nd} of September 2008, on supply equation. This variable, is also incorporated on the specification of the demand equation.

When short selling activities are not distorted by frictions (legal or market based), bad information on a company is incorporated in prices through an increase in short positions and demand of borrowing stocks. That increase in short positions, will result into a fall in prices. When prices completely reflect information, short selling activities will not be profitable, and short sellers will buy back stocks on the market. Borrowing relations are ended, and a reduction in demand follow. Consequently, I incorporate on the demand equation variables, $Lend_{it-1}$ and $Pctlending_{it-1}$, that controls for previous period borrowed stocks.

If short sellers behave as trend chasers, piling losses should lead to increases in short selling activity. This idea in mind, a market momentum variable that accumulates the return of 3 previous weeks is incorporated on demand equation.

The cheap gain, for borrowers, derived of tax asymmetries on dividend payments, lead to the introduction of a dividend related variable, $Dividendo_{it}$, on demand equation. This variable ranges from -4 to 4 according to the number of weeks to/from dividend payment date.

The relevance of the exogenous determinants of supply as instruments for demand is now presented, then illustrating the relation between exogenous determinants of demand and supply.

Past supply, S_{it-1}, correlates with present costs while being independent of current demand. The informational nature of demand conditions underlie independence of previous period supply and actual demand, while persistence of costs (funding needs) leads correlation with previously supplied amounts.

D'Avolio (2002) exposed the reasons relating market capitalization and demand. The higher market capitalization, the lower the costs due to the reduction on implied liquidity (opportunity) costs. However, market capitalization does not lead to modifications on company information and, hence, on demanded amounts.

The structural nature of borrowing lead the relation of past lending, $Lend_{it-1}$ and $Pctlending_{it-1}$, with costs. The more stocks borrowed on previous period, the higher actual costs will be. Supply of stocks will depend on funding needs, while the incorporation of lagged supply on supply equation will make present supply independent on (previous) borrowing activities.

The splitting of tax shield derived profits between lenders and borrowers, implemented through the payable rebate rate, lead directly to the relevance of the dividend related variable, $Dividendo_{it}$, when characterizing the relation between costs and supply.

The auto-correlation of market momentum measure, $Momentum_{it}$, translates on correlation between that variable and previous cost. The structural nature of borrowing costs imply auto-correlation of that variable, and hence correlation with actual market momentum. However, the evolution of market prices will not influence funding needs of holders and, hence, supplied amounts.

Table 1.4.: *Estimates of Supply and Demand Equations*

Dependent variable: Lend Interest	*I*	*II*	*III*	*IV*
Cost	1.466***	0	-0.123**	0
Past total supply of stocks for lending	0.0002***	0		
Regulatory Note September 22 2008	-1.045***	0.01		
Cost* Regulatory note	-3.740***	0.2979		
Past total supply*Regulatory note	-0.0006***	0.6995		
Lend Interest t-1			0.454***	0
Weeks to dividend			0.135***	0
Market Momentum			-0.497***	0.04
Percentile Lending t-1			-0.005***	0.15
Constant	-0.820***		0.903***	
Observations	16658		16658	
Number of groups	103		103	
*+ significant at 10%; ** significant at 5%; *** significant at 1%*				
*Instrumented in Supply Eq.: Cost, Cost*Regulatory Note; Instruments: Lending t-1, Market Momentum, Percentile of Lending t-1, Weeks to Dividend, Lending t-1* Regulatory Note*				
*Instrumented in Demand Eq.: Cost; Instruments: Supply t-1, Percentile of Market Capitalization, CNMV*Supply t-1*				

1.5.2. Supply and Demand Estimates

Table 1.4 present results for the estimation of supply and demand equations under above specification. Columns I and III correspond to the estimation of equations using within-group fixed effect estimators, whereas in columns II and IV, p-values for the Wilcoxon test of significance of each coefficient are presented, when this equations are computed at a company level. Those estimations are equivalent to testing the model that considers an stable relation across firms (the regression coefficients being the same for all companies) against a company driven behavior.

The existence of an stable relation is rejected in our sample. There exists a significant amount of information, at a company level, influencing supply and demand. The change in regulation do not seem to have modified the behavior of borrowers (estimates dropped for consistency) but lenders. After the introduction of new regulation, the slope of supply inverts (point estimates change from 1.466 to -2.274) on aggregate with results of non parametric testing, indicating the absence of inversion for most of our sample of companies at an individual level. Hence, equations are estimated at a company level to ensure representativity.

Having estimated demand and supply equations, I use residuals[10] to create a set of variables characterizing shifts:

- SOUT: Observed supply is bigger than expected supply. Residuals are positive, shorting is easier and, returns reduce. This will be typical of unexpected increases of funding needs.
- SIN:Observed supply is lower than estimated supply. Residuals are negative, shorting is more difficult and, returns increase.
- DOUT: Observed demand is bigger than expected demand. Residuals are positive, higher negative information is perceived and returns should reduce.
- DIN: Observed demand is lower than expected demand. Residuals are negative, less negative information is in place for a concrete stock, shorting is lower, and returns bigger.

Cohen, Diether, and Malloy (2007) presented a similar procedure to control for constraints in the borrowing market that could affect shorting of stocks.

1.6. Market returns, abnormal market returns and existence of bubbles

In this section, I study the interaction between borrowing stocks market, returns and abnormal returns. I, also, analyze the predictive capacity of that market on future abnormal returns. I estimate my equations using the fixed effect methodology unless explicitly mentioned, controlling for year specific effects. Finally, the relation between borrowing restrictions and the conformation of market bubbles, in the short and long run, is studied.

1.6.1. Present Returns and present abnormal returns

Table 1.5 present estimates for the relation between borrowing costs and contemporaneous returns. In line with previous results, such as Bris, Goetzmann, and Zhu

[10] On the following estimations, only residuals above 1 standard deviation are used. Changing that criteria does not change qualitatively my results

(2007), a negative relation is observed. Columns II to IV illustrate the robustness of my results, even in presence of company specifics.

Table 1.5.: *Effect of the lending market on equity returns*

Within group estimates using company and year fixed effects. The returns are ex dividend and expressed as fraction of one. Cost in percentage. Lending Interest is the percentage of total equity lent at a week. Dividendo is the number of weeks to dividend date ranging from 4 to -4. Direction is equal to one if the supply determines the price and -1 if it is demand. CNMV is one from 22 September on. Sample period Jan 2005 to Dec 2008

Dependent Variable: Return	*I*	*II*	*III*	*IV*	*V*
Cost	-0.0103***	-0.0103***	-0.0099***	-0.0100***	-0.0101***
Lending interest	-0.0037***	-0.0037***	-0.0034***	-0.0039***	-0.0039***
Dividendo		0.0000	0.0000	-0.0035**	-0.0035**
Direction			0.0057***	0.0053***	0.0053***
Cost x Direction			-0.0009+	0.0000	0.0000
Convertibles				-0.01	-0.01
Rights issuances			0.0155**	0.01	0.01
Cash to Sales				0.0000	0.0000
Leverage				0.0000	0.0000
Lending interest x CNMV					0.0000
Cost x CNMV					0.0000
CNMV					-0.01
Constant	0.0038***	0.0038***	0.0000	0.0000	0.0000
Observations	17043	17043	17043	15111	15111
Number of group	103	103	103	91	91
R-squared	0.31	0.31	0.31	0.31	0.31

*+ significant at 10%; ** significant at 5%; *** significant at 1%*

The relevance of the direction variable on stock returns is interesting. That is build using the Ellis, Michaely, O'Hara algorithm (Ellis, Michaely, and O'Hara (2000)) and reflect the market side (supply or demand) driving price formation. This variable takes the value 1 when the price is supply driven and -1 otherwise. When the price is determined by sellers, returns are a 0.5% higher. This reflects the effect of scarcity on price formation.

In column V, I study the price formation distortions induced by new short selling regulation. No effect on contemporaneous relation are found. This is in contrast with the extended view of short selling activity inducing market falls.

In Table 1.6, I present evidence on the relation between relative company performance and borrowing behavior. Column I, suggest the existence of a volatility increasing relation between borrowing costs and performance. When a stock is performing better than the market, an increase of 100 basis points in cost, increases abnormal returns in 1 percent, however when the stock is performing worse than the market (abnormal return is negative), the same increase in costs increases the size of losses in a 1 percent. Those results are robust to the introduction of company specifics (columns II to IV) and new regulation, (column V).

Endogeneity concerns, leading to inconsistency of estimates, due to the use of interactions of borrowing costs and an abnormal return related variable, make me present estimates of columns VI and VII. In those, I estimate, using a maximum likelihood random effects approach, truncated regressions for both positive and negative abnormal returns cases. Following this methodology, I rule out the existence of any relation between borrowing and relative performance when companies over-perform. However, higher borrowing activity, leading to cost increases, will worsen stock performance when that is relatively bad. This is consistent with both, a reduction of lending supply, due to a risk reduction of stock holders (market sale), and a trend chasing behavior of short sellers.

All my findings are coherent with previous literature, and stresses the informational role played by short sellers (stock borrowers). When a stock is under-performing, rational expectations lead potential short sellers to believe there is some hidden information yet to be released. Hence, they increasing borrowing activity, pushing up lending fees. Stocks are then sold in the market and the negative relation observed in data follows.[11]

1.6.2. Predictability of abnormal returns

In Table 1.7, I estimate the effect of borrowing activity on the predictability of abnormal returns. In line with findings in Jones and Lamont (2002) and Cohen, Diether, and Malloy (2007), a negative relation is found. An increase of 100 basis

[11]Goldstein and Guembel (2008)for further theoretical discussion

Table 1.6.: *Effects of the Lending Market on Abnormal Equity Returns*

Within group estimates using company and year fixed effects. The abnormal returns are computed applying CAPM equation with a value weighted Index, expressed as fraction of one . Cost in percentage. Lend Interest is the fraction of total equity lent. Dividendo is the number of weeks to dividend date ranging from 4 to -4. Direction is equal to one if the supply determines the price and -1 if it is demand. CNMV is one from 22 September on. Sample period Jan 2005 to Dec 2008

Dependent variable: Abnormal Return	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*
Cost	-0.0082***	-0.0082***	-0.0078***	-0.0078***	-0.0079***	-0.0011***	0.0003
Cost x Abnormal return>0	0.0176***	0.0176***	0.0175***	0.0174***	0.0174***		
Dividendo		-0.0000	-0.0000	-0.0000	-0.0000	-0.0015	-0.0025
Direction			0.0042***	0.0041***	0.0041***	0.0018***	0.0008+
Cost x Direction			-0.0007**	-0.0006**	-0.0006**	-0.0002+	0.0002
Lending interest x Direction			0.0000	0.0000	0.0000		
Convertibles			-0.0000	-0.0000	-0.0000	-0.0077+	-0.0090+
Rights issuances			0.0076**	0.0064+	0.0064+	-0.0050	0.0152**
Cash to Sales				0.0000	0.0000	0.0000	0.0000
Leverage				0.0000	0.0000	0.0000	0.0000
Lending interest x CNMV					0.0000		
Cost x CNMV					0.0000		
CNMV					0.0000	-0.0147***	0.0202***
Constant	0.0010**	0.0010**	-0.0011+	0.0000	0.0000	-0.0152***	0.0251***
Observations	17043	17043	17043	15111	15111	7978	7133
Number of group	103	103	103	91	91	91	91
R-squared	0.41	0.41	0.41	0.41	0.41		

*+ significant at 10%; ** significant at 5%; *** significant at 1%*

points in borrowing costs will, on average, reduce future abnormal returns in a 0.1 percent. When a higher amount of negative information is perceived, the amount of stocks borrowed, and costs, increases. Market sales, then, lead to price falls and company stocks under-perform the market.

In columns II to IV, I analyze the effect of different borrowing supply and demand shifts (constraints) on future abnormal returns. If short selling activity underlie market falls, unexpected reductions on borrowing demand should have a positive impact on future stock returns. This due either to the fact that stock prices are accurately reflecting information available, and short sellers netting their positions, or because better perceptions on future company performance are held.

Results on columns II and III point towards the relevance of supply side restrictions to understand interactions between lending and stock markets, while changes on demand will not affect performance. As supply changes would be driven by funding and capital constraints, while demand is determined by information, I conclude, making use of previous results, that market liquidity (characterized by abnormal returns), is only affected by changes on funding and capital conditions, short sellers behaving as trend chasers.

To confirm my findings, column IV presents regression results when including a tighter restriction on borrowing conditions. This, considers those situations in which a simultaneous reduction in supply and an increase in demand took place. The effect of this variable on future abnormal return is less significant than the one that just considers supply shifts (significance at a 10 percent level) and of bigger, but not significantly different, magnitude. Supply side restrictions are, consequently, the ones relevant to understand stock performance.

Table 1.7.: *Lending market effects on abnormal returns predictability*

Within group estimates using company fixed effects. The abnormal returns are computed applying CAPM equation with a value weighted Index, expressed as fraction of one . Cost in percentage. Lend Interest is the fraction of total equity lent. Dividendo is the number of weeks to dividend date ranging from 4 to -4. Direction is equal to one if the supply determines the price and -1 if it is demand. CNMV is one from 22 September on. Sample period Jan 2005 to Dec 2008

Dependent Variable: Abnormal returns t+1	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*
Cost	-0.0017***	-0.0017***	-0.0017***	-0.0018***	-0.0018***	-0.0016***	-0.0011***
Cost x Abnormal return t >0	0.0001						
DIN		0.0002					
SIN			0.0011**				
SIN & DOUT				0.0014+	0.0014+	0.0014+	0.0013+
Dividendo					-0.0027**	-0.0036**	-0.0038***
Direction						-0.0012+	-0.0012+
Cost x Direction						-0.00003	0.00006
Convertibles						-0.0301***	-0.0291***
Rights issuance						0.0017	0.0010
Cash to Sales						0.00001	0.00001
Leverage						0.0000	0.0000
Cost x CNMV							-0.0024***
Constant	0.0011**	0	0	0.0010**	0.0011**	0.0021***	0.0018**
Observations	17246	17246	17246	17246	17246	15043	15043
Number of group	103	103	103	103	103	91	91

*+ significant at 10%; ** significant at 5%; *** significant at 1%*

The possibility of bias, due to the existence of non-modeled company specifics driving my findings, lead me to compute additional regressions incorporating a wide variety of firm and market related variables (direction, weeks to dividend, existence of convertibles and right issuances, Cash to Sales and Firm Leverage) with no modification in results (columns V and VI). From these variables, two are of special relevance: direction and convertibles.

When previous market price was supply determined (direction variable equal to one) future abnormal return is lower. Previous results post evidence on the existence of a positive relation between contemporaneous returns and direction, coherent with trend chasing behavior. On the other hand, results on abnormal returns illustrate the existence of market overreaction. If the market overreacts to news, so agents are just partially informed, a positive abnormal return in one period should be followed by a correction, subsequent abnormal returns being of smaller size.

Even though convertible issuances are scarce in our sample (just two are present), those are related with a relatively worse performance in terms of abnormal returns. This is in line with findings in Bris, Goetzmann, and Zhu (2007) and consistent with the dilutory effects arising from its conversion into new equity. While both, equity an convertibles are quoted in the market, agents have the possibility of trading through any of them. At convertible's maturity, the sum of conversion price and convertibles market price should equal the price of the stock. Then, stock returns will be splitted between both products and abnormal returns will be lower.

Results on the effects of regulatory (legal) restrictions on short selling are presented in column VII. Following the introduction of regulation, the relation between borrowing and stock markets increases. The tightening on the borrowing schedule underlies this result. The increase in borrowing costs (lending fees), following the increase on daily borrowing demand, would lead short sellers to require a higher reduction of stock prices to accommodate for both, the increase in funding costs and negative company information. Untabulated results by percentile of market capitalization confirm the results here presented, while pointing towards a higher impact on middle capitalized companies (those belonging to the 40-70 capitalization range).

1.6.3. Stock Lending and the 2008 Market Crash

1.6.3.1. Short term evidence

In this section, I turn to the determination of the role played by borrowing markets on the creation of stock bubbles. The idea of short selling restrictions leading to the creation of market bubbles was initially incorporated in Miller (1977), developed by Jones and Lamont (2002) and widely explored by Hong, Lim, and Stein (2000). Restrictions to borrowing will translate on short selling restrictions. Those will increase the difficulty of impounding negative information on stock prices, leading to stock overpricing.

To study the presence of such relation, I start by creating a variable that characterizes the difference between fundamental and market price of stocks in the short run. That is computed as the ratio of market to book values, for each week, and year end market to book value. Market value is computed as the product of number of equity shares and end of week closing price.

A positive relation between this measure and borrowing costs is found (Table 1.8), even when company and market specifics are considered. Companies facing yearly reductions on market to book value ratios have been more heavily borrowed (positive relation between borrowing costs and volumes) while changes on borrowing conditions does not affect my results (column VI). This reflects the role of borrowers as price efficient agents. Discrepancies between market and fundamental company value are cleared off the market by increases on borrowing activities.[12] Further evidence on this behavior is presented in the following section.

1.6.3.2. Long term evidence

Subsequent to the results on the short term relation between market bubbles and borrowing activities, I analyze the effect of borrowing constraints on the long run performance of stocks. To this end I measure the accumulated increase in market to book value ratio from March 2008 to December 2008, and for the same period in 2007. This period is not chosen arbitrarily. Following the fall of Bearn & Stearns in March 2008, the financial crisis become more visible and short selling activities

[12] I also verify the robustness of our results to capitalization and lending size running the same regressions by percentile of market capitalization and percentile of lending volume. I find an asymmetric relation when firms are pooled by market capitalization while no qualitative changes are found according to lending volumes. Bigger companies are affected by the existence of borrowing constraints (DIN, SIN and SIN&DOUT variables). As the amount of stocks to be sold, for negative information to be perceived, is bigger, restrictions to borrowing affect more market liquidity and prices.

__Table 1.8.:__ Lending market effects on short term bubbles creation

Within group estimates using company fixed effects. Market to book value is computed as the value of market to book value relative to this ratio the last trading day of December. Cost in percentage. Lend Interest is the fraction of total equity lent. Dividendo is the number of weeks to dividend date ranging from 4 to -4. Direction is equal to one if the supply determines the price and -1 if it is demand. Sample period Jan 2005 to Dec 2008.

Dependent Variable: Market to Book	*I*	*II*	*III*	*IV*	*V*	*VI*
Cost	0.0837***	0.0842***	0.0876***	0.0877***	0.0879***	0.0928***
DIN	-0.01					
SIN		0.01				
SIN & DOUT			-0.0569***	-0.0577***	-0.0576***	-0.01
Weeks to dividend				0.0001	0.0001	0.0001
Rights issuance					-0.1842***	-0.2019***
Convertibles					0.2204***	0.2868***
Cash to Sales						-0.0021***
Leverage						-0.00001***
Constant	0.9658***	0.9567***	0.9629***	0.9629***	0.9571***	0.9778***
Observations	17043	17043	17043	17043	17043	15111
Number of group	103	103	103	103	103	91
R-squared	0.02	0.02	0.02	0.02	0.02	0.04

*+ significant at 10%; ** significant at 5%; *** significant at 1%*

were banned from the market in subsequent months. Market manipulation concerns underlie those decisions. To test for the existence of an asymmetric effect of short selling activities during this sample period, the same period of 2007 is included as a seasonality control.

Opposite to previously used weekly variables, a new set of variables is computed. I aggregate the number of weeks with borrowing supply and demand shifts, to measure borrowing activity constraints. Borrowing costs are computed as the weighted average, by borrowed amount, of weekly lending fees. Hence, regression coefficients should be understood as the long run effect of borrowing activities (between estimator), as proposed by Mundlak (1978).

Regression results displayed in Table 1.9 illustrate the irrelevance of borrowing constraints, in the long run, for the formation of bubbles. Borrowing activity, on the other hand, continues to be significant while those companies that experienced higher overvaluation, in previous period, also suffer stronger price reductions. This adds to results on previous section, and to short term effects of short selling constraints found in Bris, Goetzmann, and Zhu (2007), pointing towards the existence of pricing on fundamentals in the long run. Borrowing activities increase the speed at which price adjustments take place, while long run price efficiency is granted, even in presence of lending rigidities.

Table 1.9.: *Lending Market effects on long term bubbles creation*

Within group estimates using company fixed effects. Market to book value is computed as the value of market to book value relative to this ratio the last trading day of December. Increase in MTB is the increase in Market to book from March to December. Cost mean is the weighted by volume cost of lending expressed in percentage.Sample period March 2007-Dec 2007 and 2008-Dec 2008.

Dependent Variable: Increase in MTB 2008	*I*	*II*	*III*	*IV*	*V*	*VI*
Increase MTB 2007	-0.0833***	-0.0834***	-0.0873***	-0.0845***	-0.0877***	-0.0922***
Average fee 08	-0.0421***	-0.0416***	-0.0368**	-0.0413***	-0.0367**	-0.0305+
Weeks demand<0		-0.0012			-0.0024	0.0013
Weeks supply<0			-0.005		-0.0032	-0.0004
Weeks supply<0 & demand>0				-0.0028	-0.0034	-0.0017
Rights issuance						-0.01
Convertibles						-0.05
Percentile of lending volume 07						0.0030
Constant	-0.2734***	-0.2428***	-0.1458+	-0.2546***	-0.11	-0.18
Observations	76	76	76	76	76	76
R-squared	0.16	0.16	0.19	0.17	0.19	0.2

*+ significant at 10%; ** significant at 5%; *** significant at 1%*

1.7. Conclusions

In this chapter I have studied the interactions between borrowing and stock markets. As in previous papers, Bris, Goetzmann, and Zhu (2007), Jones and Lamont (2002), D'Avolio (2002), a negative relation between contemporaneous returns and short selling activity, characterized by borrowing costs, is observed. The higher borrowing costs, the lower stocks returns. This relation has not been affected by the introduction of legal constraints to short selling activity.

The relation between borrowing and stock markets is further explored. Borrowing costs and relative stock performance (abnormal returns) exhibit a negative relationship. It occurs when performance is worse than the market, even when company specifics are considered. In contrast with the assumption in Goldstein and Guembel

(2008), short sellers behave as trend chasers. As proposed by Miller (1977), legal constraints to short selling resulted on an increase on abnormal returns volatility. This has to be understood in terms of the liquidity role of short selling activities. Short selling activities help to increase stock liquidity and, thus, price efficiency.

Also, borrowing activities are relevant to predict future relative performance. As for the contemporaneous relation and in line with findings in D'Avolio (2002), borrowing costs and future abnormal returns are negatively related. This relation was reinforced after the introduction of legal constraints to short selling. My results highlight the crucial role of stock lenders to understand future stock performance, while increases of negative information that push up borrowing demand will not affect future performance. Irrelevance of borrowing demand changes, strength the perception of short sellers as trend chasers. My results on relevance of supply-side constraints, to predict stock performance, are in line with findings in the arbitrage theory (see Gromb and Vayanos (2002), Kyle and Xiong (2001a)). Modifications on funding and capital needs, will affect borrowing supply and then market liquidity and prices.

Borrowing markets also affect the conformation of bubbles, both in the short and the long run. Higher borrowing activities, reflected on cost increases, lead to reductions on stock overvaluation. However, unpredicted changes on the borrowing market do not affect stock values, in general. Only highly-capitalized firms are affected by borrowing constraints. This arises as the result of the difficulty on impeding negative information on stock prices for those companies. Highly-capitalized firms are also highly traded, hence, the amount of stocks to be borrowed for shorting activities to be relevant is also high.

Evidence in favour of market overreaction is, also, found. Stock prices and fundamental values converge in the long run. Stocks beating the market for a period of time, underperform on subsequent periods. Borrowing activities both, increase the speed at which this process happens and reduce market overvaluation.

A. Variable Definitions

- Lend Interest: It is computed as the ratio between total number of equity shares borrowed in a week and the total number of equity shares of the company
- Direction: It is computed using the Ellis, Michaely, O'Hara algorithm at a daily level and aggregating. This algorithm assigns the value 1 if the ratio $\frac{2*(ask_t - close_t)}{ask_t - bid_t}$ is smaller than one for more than 2 days in a week, otherwise the value is 0
- Cost: The cost of borrowing is computed as follows. If the loan is cash collateralized it is the difference between one day Libor and the Rebate rate. If the loan is not cash collateralized it is the fee of the loan. To get cost at a weekly level a weighted by daily lending volume cost average is computed
- Dividendo: It is the number of weeks to dividend, takes the value 1 for the week in which dividend payment is done. It ranges from 4 to -4.
- CNMV: It takes the value 1 from 22 September 2008 on. In any other case it is 0.
- Leverage: It is the ratio between Short Term Debt and Cash Flow.
- Cash-to-Sales: It is the ratio of Cash Flow to Total Sales
- Right issuance: It is 1 for the period whilst rights are traded in the market
- Convertibles: It takes the value one for the week in which convertible bonds are issued
- Market to Book: It is the ratio of Market to book value for a week and the same value the 31st of December of that year
- Cost Mean 08: It is the weighted mean of borrowing cost from March to December using as weights lending volumes.
- Increase MTB: It is the increase in Market to Book ratio from March to December. It is computed as the inverse of Market to book ratio minus one.

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Chapter 2.

Limit Arbitrage Implications on Bank Capital

Abstract

Here, I present a two state dynamic equilibrium model for the determination of optimal bank capital. Banks are assumed to have access to two types of default tradable assets and to equity markets every period. It relies on limiting arbitrage theory to derive the results. Endogenously determined capital constraints play a central role on my model. Banks hold endogenous capital buffers as a precaution against potential dilution, bankruptcy and to guarantee access to arbitrage opportunities. On recessions, endogenous capital constraints lead to the prevalence of equity markets as the preferred recapitalization mechanism, with refinanciation processes motivated by the chance of resurrection. On expansions, deleverage techniques prevail. Limited capital leads to the collapse of primary and secondary markets of private credit by inducing arbitrage between equity and loan markets. This points towards the convenience of an increased monitoring of market prices to ensure correct pricing of risks. The modeling of asset markets allow me to analyze, from a social welfare perspective, the effects of regulatory actions on markets: Bond and Loan purchases. While buying bonds will lead to welfare increases under any capital choice, loan purchases are only welfare increasing when equity and loan markets are aligned.

Resumen

Aquí, presento un modelo dinámico de equilibrio para la determinación del capital bancario óptimo. Se asume que los bancos tienen acceso a dos tipos de activos transables sujetos a riego de impago y a los mercados de acciones en cada periodo. Los resultados se basan en la teoría de los limites de arbitraje. Las restricciones de capital determinadas endógenamente juegan un papel central en mi modelo. Los bancos mantienen colchones de capital para protegerse contra el riego de dilución, la bancarrota y para garantizar su acceso a las oportunidades de arbitraje. En las recesiones, las restricciones endogenas de capital conllevan a la prevalencia de los mercados de capital como mecanismo preferido de recapitalización, los procesos de refinanciacion motivados por la oportunidad de resurrección. En las expansiones, las técnicas de desapalancamiento prevalecen. Los limites de capital llevan al colapso de los mercados primarios y secundarios privados de crédito, induciendo arbitraje entre los mercados de acciones y préstamo. Esto sugiere la conveniencia de una monitorización incrementada de los precios de mercado para asegurar la correcta valoración de los riesgos. La modelización de los mercados de activos me permiten analizar, desde un punto de vista de bienestar social, los efectos de las acciones regulatorias en los mercados: compras de bonos y préstamos. Mientras comprar bonos conlleva incrementos de bienestar bajo cualquier elección de capital, las compras de préstamos solo incrementan el bienestar cuando los mercados de acciones y préstamo estan alineados

2.1. Introduction

Following the burst of the sub-prime crisis in 2008, a massive reduction of outstanding credit contracts has been observed. Also growth rates, bankruptcies, unemployment and poverty, have deteriorated[1]. In the aftermath of Lehman Brothers bankruptcy, regulators deemed necessary to re-capitalize banks. Authorities of some countries[2] have taken strong market actions (Quantitative Expansions) to ensure the quick recovery of credit activities and profits, while some others[3] have followed a more normative approach instead.

In Europe, ECB[4] implemented, recently, non-conventional instruments of monetary policy, to channel credit back to economy, via:

1. The purchase of ABS[5] intents to reduce capital needs, by transferring assets from commercial banks to ECB.
2. Negative interest rates to restore interbank market, severely damaged by the uncertainty of bank capital quality.
3. Long-term refinancing operations linked to liquidity creation, such as the TLTRO[6], designed to help the recovery in primary credit markets.

I analyze monetary instruments, as ECBs, and I also seek to formalize the relation among bank capital, credit and equity markets. Doing so, I follow Repullo and Suarez (2013), set up of the world, with a main difference I use limit arbitrage theory, see Kondor (2009), to generate frictions endogenously. Therefore now, capital buffers are produced organically in my model via the optimizing behavior of bank managers, requiring to equalize cost of capital and trading profits. This is in contrast with previous studies[7], where capital buffers arise from limited competition or

[1] In Europe for the period 2008-2014, outstanding loans to private sector reduced 0.55% per year compared to an 8.5% of growth for the period 2003-2008, growth rates have dropped from 1.5% to 0.15% and unemployment increased from 9.8% to 11.8%. according to data from ECB and Euro-stat

[2] Amongst others U.S., Japan, UK or Canada

[3] Essentially those belonging to the European Monetary Union

[4] It was not before 2014, when EU set ECB as a common supervisor in the euro-zone.

[5] Asset Backed Securities

[6] Targeted Long-Term Refinancing Operations

[7] While some papers like Suarez (1994) or Repullo and Suarez (2013) illustrate the determination

from asset illiquidity. Various studies on the limits of arbitrage[8] document that a general equilibrium model incorporates frictions via the existence of risky arbitrage opportunities.

It is further assumed, perfect mobility of borrowers among entities and loan refinancing at the end of first year. Perfect mobility in borrowers signals perfect competition in primary loan markets. Borrowers are not tied up to entities through relational lending and interest rates are uniform. Loan refinancing would give the possibility to reset rates and extend maturity from the initial 2 period to three. This is important because it adapts better to the loan market reality where loans are not payed up but are rather refinanced. This extends Repullo and Suarez (2013).

External shareholders would price banks according to book value, and they would be risk averse and with no capital constraints. They are risk averse in the sense that external shareholders will be reluctant to buy equity of any institution holding capital below regulatory level. Such investors would be an opportunity cost for existing shareholders. When economy deteriorates (higher VaRs and lower prices) those investors become more important, leading to capital injections and symmetric bank capital equilibrium. This behavior is in line with findings in Estrella (2004) and Peura and Keppo (2006).[9]

I endogenously generate capital scarcity which justifies the existence of an ordered recapitalization scheme, in contrast with the indifference condition, see Admati et al. (2012). My model suggests that when the ratio of arbitrage capital relative to recapitalization capital falls below some threshold, the indifference point, there will be misalignment in equity and loan portfolio returns. As a result, secondary loan market would collapse, and recapitalization is only possible through equity markets

of optimal capital buffers in absence of capital raising processes, or consider the existence of arbitrage opportunities based on ad hoc assumptions regarding asset liquidity, an analysis of the welfare implications of market actions is unfeasible without considering asset liquidity as an outcome of the optimization process of bank managers

[8]Zigrand (2004), Kyle and Xiong (2001b), Basak and Croitoru (2000), Gromb and Vayanos (2002), Xiong (2001), and Kondor (2009) to name just a few

[9]I derive the same results without having to assume time and liquidity rigidities. The implications of imperfect asset liquidity for bank capital determination were initially analyzed in Pennacchi (1988) while the relation between imperfect equity liquidity and capital regulation has been widely analyzed under both dynamic (Winter (1994) and Froot and Stein (1998)) and static (Winter (1991), Blum and Hellwig (1995), Heid (2005), and Hoggarth, Reis, and Saporta (2002)) frameworks.

thus pushing up bank value. When the ratio is higher than the threshold level, the new equity issues will collapse. Similar results are found in Acharya, Shin, and Yorulmazer (2013). Recapitalization through equity, reduces both capital buffers and liquidation threshold, will have a negative welfare effect for the state guarantees on bank deposits.

Capital unregulated assets are also present in the setup via bonds, subject to the same default risk, as loans, and paying no interest rate. The bond market effect on the capital ratios is determined by arbitrage conditions. If arbitrage opportunities, between loan and equity, are present, the higher the weight of bonds on the total portfolio the lower capital ratios. Due to regulatory arbitrage, managers would substitute new loans, by bonds.

The rest of the paper is organized as follows: In section 2, I set-up the model. In section 3, I solve for the optimal trading decision of a single bank and characterize the global equilibrium determining optimal bank capital and interest rates. In section 4, I present comparative statistics. Section 5, presents a model calibration and numerical results on capital buffers, failure probabilities, existence of rationing, loan rates, secondary market prices and trading. In section 6, I attempt a social welfare analysis on ECBs policies. In section 7 I conclude.

2.2. The Set-up

Here is a summary of the model framework:[10]

- There are two types of credit assets in the economy, bonds and loans. Bonds, of one year maturity, are conditioned by default probability but they are not subject to capital regulation. Loans are two year tradable assets at inception, that could, later on, be refinanced, or traded. Loans are subject to capital regulation.

[10] This framework should be interpreted as a simplification of the environment faced by banks that develop their activities under the supervision of a common authority (such as the ECB), where private entities borrowing money do not differ by their managerial quality but are exposed to economic shocks affecting their payment capacity.

- I assume a free entry economy with two states. The primary credit market is perfectly competitive,[11] and under a regulatory environment fixed by a supranational authority. Regulation takes the form of a minimum capital to asset ratio threshold common to both equity and loans.[12]

- Any bank operating in the economy is subject to an idiosyncratic default risk that depends only on the state of the economy.[13] The default rate of the portfolio is common to bonds and loans, within an entity, but varies across entities.[14]

- Banks have the possibility to raise equity from external investors.

For the welfare analysis I need an additional assumption:

Assumption 1. *There can be a value transfer from previous capital constrained shareholders to a new generation of rich shareholders.[15]*

[11] The surge of the number of participants in the credit market, due to the appearance of hedge funds, crowd funding and direct lending, and the increased availability of credit quality information during recent years, have raised borrowers capacity to migrate from one entity to another justifying perfect competition in primary markets.

[12] An homogeneous regulatory treatment of loans and equity, could seem inaccurate given the existence of penalties on the tenency of equity instruments among regulated institutions. A shortcut to a full modeling of the effects of such penalty, which would introduce discontinuity in asset demand, is taken incorporating it through non-financial expenditures of equity. This shortcut is sustained in present regulation regarding equity holdings which does not depend on default probability. Under this, Banks holding equity instruments of other regulated institutions should either deduce from the Common Equity Tier 1 the 90% of those or assume a 250% asset Risk Weighting (RW) on their positions.

[13] Differences on the diversification strategy, from one financial entity to another, will lead to differences in default rates across entities

[14] Economic shocks exhibit positive correlation with the state of the economy, while this positive correlation leads to positive correlation of financial assets among themselves.

[15] Under this assumption, arbitrageurs will see no interest in transferring shares, leaving this task to bank shareholders who already have, two year maturity, loan portfolios. Bank managers, will ask new shareholders for new capital until they reach the optimal capitalization level. Investors outside the financial sector will be providing the new capital needed, because they are deciding based on book value rather market value of the bank. This raises welfare concerns. Money used to recapitalize banks could, alternatively, be used to create new entities.

2.2.1. The assets

2.2.1.1. Bonds

Bonds bought in auction, in the sense of Menezes and Monteiro (1995), promise to pay the notional at maturity. The bond price, $B = B(s)$, will only depend on current state of the economy, s, and it is subject to default risk, with recovery value $1 - \lambda$. Bond supply is exogenous, but I adopt the optimality condition seen in Greenwood, Hanson, and Stein (2010), to describe how the governments manage fire-sale risk, by selling bonds at the expense of short term private debt.

2.2.1.2. Loans

Loans are financial instruments designed to provide funding, per unit of investment opportunity, a penniless investor demands. These are risky investment projects that either pays μ , or 0. [16] The level of state contingent fixed rate, r_s, stipulated in the two year loan agreement, is competitively determined. Loans are fully repaid at maturity.[17] I allow for re-financing to occur at intermediate date. The bank receives $1 - \lambda$,[18] when the loan defaults and the entrepreneur receives nothing.

Further, banks could use secondary loan market to offload remaining one year loans to other, regulated, financial entities. The market clearing price, P', for such a transaction will be state, s, contingent and homogeneous,[19] $P' = P(s'|s) = 1 - \sigma'$.

2.2.1.3. Equity

Any existing bank is assumed to have one unit of shares issued to existing shareholders. Those shares, are equity instruments representing a contingent claim on

[16] μ, includes social gains.

[17] The absence of amortization schedule is typical in corporate bonds and bullet loans, and in any case, does not affect the findings of the paper.

[18] Commonality on loss given default of loans and bonds, λ, does not modify the conclusions of the paper

[19] Price homogeneity, should be understood as a simplification of the environment faced by credit traders that, knowing the capital costs associated to the tenency of loans, observe a price in the market and decide if they are interested in buying/selling those.

bank capital. New equity could be issued by existing banks, at rate , Δn_i^b, and share price, P_i', being $P_i' = P_i\left(s'|s\right)$. Each equity buyer invest Δn_i^n of their loan portfolio in a well diversified, and representative equity portfolio tracking a banking index of weighted average, new share, prices, P_x'.

2.2.2. The economy

My economy behaves as a two state, $s = \{l, h\}$, Markov chain. Agents are fully informed about the state of the economy when taking their decisions. The shifting probabilities from s to h are denoted by $q_{s,h}$. Default probabilities are ranked, in the sense of first order stochastic dominance, while the average failure rate, p_s, common[20] for the two assets, is contingent on the state of the economy, s, so that:

$$p_h = \int xdF_h(x) \geq \int xdF_l(x) = p_l$$

where $F_s\left(x\right)$ is the cumulative distribution function of the failure rate , x, under state s, and the states of the economy, $\{h, l\}$, could be interpreted as recession (high probability of default) and expansion (low probability of default) periods.

2.2.3. The Banks

Banks are competitive entities channeling funds from depositors/investors to the economy. At any date, banks are funded through deposits and equity capital, and this funding is used either to give loans to entrepreneurs (liquidity creation) or to purchase assets in secondary markets (trading activities).

Deposit supply is assumed to be completely elastic with zero deposit rate allowing the banks to serve the demand for loans. They will charge a rate, r_s, for loans on

[20] If bonds are assumed to be instruments representing government debt, commonality is a simplification of the existing relation between public income and loan default. Reputational costs due to non-recapitalization, as in Segura (2013), justify the commonality of default rate and recovery rates when bonds are off-balance credit operations hold in SPVs without recourse.

top of the risk free rate. Bank shareholders require a, time invariant, excess return, $\delta \geq 0$, per unit of capital invested.

Banks are managed in the interest of existing equity holders (summarized by capital of the bank), protected by a limited liability assumption and subject to a state contingent capital requirement[21], γ_s, per unit of asset.

Banks hold a portfolio of legacy assets (loan and equity portfolio) from previous period lending activities, $L^e = L^e\left(s\right)$, with endogenous capital level, $K' = K\left(s'|s\right)$. Banks are also assumed to face non financial expenditures[22], c, per unit of credit asset (bond or loan) held in the portfolio in previous date. The equity in the portfolio also faces non-financial cost, c^e. In this case, non financial costs include the regulatory differentiation between equity and credit assets.

Those banks with capital ratio, $k' = k\left(s'|s\right) = \frac{K'}{L^e} > \gamma_{s'}$ have the possibility to reduce/increase their portfolios, to increase capital or do nothing. If capital ratio is below the regulatory level, $k' < \gamma_{s'}$, managers will have to present a recapitalization plan, involving loan sales, capital injections or a mix. If the bank fails to recapitalize, authorities will take control under a process driven by the following assumption:

Assumption 2. *Any bank with insufficient capital, is nationalized. Shareholders receive nothing, and assets are held until maturity.*

I are ready to establish the evolution of capital, K', and loans, L^e:

Definition 1.
The level of endogenous capital, K', and residual portfolio of loans, L^e, are:

$$
\begin{aligned}
L^e &= \left(1-x\right)L \cdot 1_{\{\Omega=0\}} \\
K' &= \left[r_s + k_s - c_i + \Delta_i \bar{r_{s'}} + \Omega\sigma - x\left(r_s + \lambda_i\right)\right]L
\end{aligned}
$$

with $c_i = c - \alpha_i\left(1-c-B\right)$ being the effective managerial costs, $\lambda_i = \left(1+\alpha_i\right)\lambda$ the loss given default of the joint credit portfolio, α_i the bond share in the loan portfolio.

[21] To guarantee comparability, in this paper I assume that the capital requirement is set according to Basel II formula on corporate loans under the standard IRB approach whose formula is presented in the appendix.

[22] This expenditure relates to managerial costs from holding previous period assets

$\bar{r_{s'}} = \frac{P'_x-(1+c^e)P_x}{P_x}$ *is the net return and* $\Delta_i = \frac{\Delta n_i^n}{L} P_x$ *is the equity portfolio share.* $\Omega = \frac{\chi}{1+\chi}$ *is the portion of loans acquired in previous period,* $k_s = \frac{K+\Delta n^b P'_i - \xi\sigma L^e}{L}$ *is the previous period capital-to-loan ratio,* σ *is the capital gain/loss due to loan trading,* $L = (1-\xi) L^e \cdot 1_{\{\xi>0\}} + \frac{1}{1-\Omega} L^e \cdot 1_{\{\Omega>0\}} + max\left(\frac{k}{k_s^*}, 1\right) L^e 1_{\{\Omega=\xi=0\}}$ *is the loan portfolio in previous period,* ξ *the share of the loan portfolio sold, and* x *the default rate.*

In the following section I present the optimal decision of bank managers on trading quantities $\left\{\xi, \Delta n^b, \Delta n^n, \Omega\right\}$, contingent on respective asset prices, $\{P, P_i, B, P_x, P'_x\}$, capital ratio and interest rate, $\{k_s, r_s\}$. Then, the value function arising from the optimization process is derived. Further, I determine the market clearing prices for both equity and loan markets, $\{P, P_x\}$. I conclude with a discussion on conditional, on the state, optimal pair $\{k_s^*, r_s^*\}$.

2.3. Equillibrium

2.3.1. Trading Decision and optimal value function

In this section I present the major results of the optimization problem solved by bank managers in form of propositions and corollaries. See appendix for formal proofs.

Given the zero profit condition,[23] leading to the determination of bond prices, and the homogeneity[24] of the problem faced by bank managers, one period ahead maximum bank capital, (that obtained when $x = x_s = 0$), could be rewritten as:

$$K = r_{s'} + k_{s'} - c + \Delta \bar{r_s} \tag{2.1}$$

where I make , $c = c_i$, $\lambda = \lambda_i$ and $\Delta = \Delta_i$.

[23]The expression for zero profit condition is $V_s\left(k_s, P^{u*}|r_s^*\right) = k_s$, with $V_s(.)$, is the optimal value function presented later, in the paper. See appendix D for full analysis.

[24]Homogeneity is implied by both assumption 1 and definition 1. They further guarantee that optimal decisions are not determined by legacy assets.

Now, let me denote by β the discount factor, $\beta = \frac{1}{1+\delta}$, and define the upper bound for loan prices, $\overline{P} = \overline{P}(s', s) = 1 - \bar{\sigma}$, beyond which losses occur as:

$$\overline{P} = \underset{P}{arg}\ \pi_s(P) - \gamma_s = 0 \tag{2.2}$$

where, $\pi_s(P) = \beta(r_{s'} + \lambda) \int_0^{\frac{r_{s'}+\gamma_s - c + 1 - P}{r_{s'}+\lambda}} F_s(x)\, dx$.

Let me further define the state contingent expected profits, $\sigma^a = \sigma^a(s|s')$, as:

$$\sigma^a = \pi_s - \gamma_s \tag{2.3}$$

with $\pi_s(1) = \beta(r_{s'} + \lambda) \int_0^{\frac{r_{s'}+\gamma_s - c}{r_{s'}+\lambda}} F_s(x)\, dx$, the discounted expected value of a normalized loan portfolio, acquired at par, under the minimum regulatory capital.

Finally, let me define the fair price of loans, in absence of capital regulation and limited liability, $P_l = P_l(s|s')$, as:

$$P_l = 1 - \sigma_l \tag{2.4}$$

where $\sigma_l = p_s(r_{s'} + \lambda) + c - r_s$, is the credit spread.

Then, in the following proposition, I illustrate the relation[25] between the three variables.

Proposition 1. *There exists an almost exact relation between funding profits, σ^a, maximum price , $\overline{P}$, and fair price, P_l, such that:*

[25] While this relation is not exact, simulation results shown in Figure A.1 in the appendix illustrate the difference between the value of those magnitudes using the numerical evaluation of the integral and approximated formulas, for different values of the average default rate, p_s, and previous period interest rate, $r_{s'}$. Also, it could be proved that the difference between both approximated and real values reduces when average default probabilities increase while being increasing on interest rates. However, even for polar cases of small default probabilities and high interest rate simulation results illustrate how this distance is kept at levels below 1bp.

$$\begin{aligned} \overline{P} &\approx P_l - \delta\gamma_s && (2.5) \\ \sigma^a &\approx -\beta\bar{\sigma} && (2.6) \end{aligned}$$

The above equations show the mechanics of the economy. If regulatory capital increases, it will reduce the range of feasible prices and portfolio profits, due to the rise of the funding cost in the economy. Rise of regulatory capital could even lead to market collapse, should the loan price be very low. The maximum value attained is affected by the state of the economy, that could deteriorate, pushing p_s up. That, would have negative effect on fair values and portfolio profits while increasing capital requirements and asset volatility.

Proposition 2. *For each bank, the relation between loan price and its maximum is:*

$$\overline{\sigma} = \begin{cases} \sigma_i - \sigma_i \frac{\gamma_s}{k}, & \overline{\sigma} > 0 \\ \sigma_i + \delta\sigma_i \frac{\gamma_s}{k}, & \overline{\sigma} \leq 0 \end{cases} \tag{2.7}$$

The expression[26] is exact when the maximum loan price is below par. If above par, then I have approximated solution.[27] 2.7, shows that regulatory shocks are asymmetric on prices. If the economy is in recession, the impact on prices is bigger due to capital scarcity.

For a certain capital threshold, $k = \bar{k}$, banks will have the market valuation for loans, resulting in $\sigma_i = \sigma$. For $k > \bar{k}$, it is $\sigma_i < \sigma$, arbitrage opportunities are present and expected bank value[28] is given by proposition 3:

[26] Acharya, Shin, and Yorulmazer (2013) produced similar results using a different model. They don't allow hedging adverse shocks like a default event via deleveraging.

[27] See Figure A.2 in the appendix of this document.

[28] Assets are acquired until the regulatory restriction is binding, $\Omega = \frac{k-\gamma_s}{k}$ due to the marginal reduction in funding costs. They compensate the rise of portfolio risk by reducing capital ratios. The funding costs present a linear relationship (linear payoff) in portfolio size while the portfolio risk is concave.

Proposition 3. *A bank holding capital $k > \bar{k}$, will buy the maximum feasible amount of loans, $\Omega = \frac{k-\gamma_s}{k}$. The expected bank value, $V^1 = V^1(s|s')$, is given by the following expression:*

$$V^1 \approx K\left(1 + \beta\frac{\sigma - \bar{\sigma}}{\gamma_s}\right) - \beta\sigma L^e \tag{2.8}$$

The expected value of the bank will be determined by the sum of its capital and trading income less mark-to-market loan valuations.

Given that a trading bank will always be subject to regulation capital, I can work out equity portfolio and loan weights:

$$\Delta = (1 - \Omega)\frac{k}{\gamma_s} - 1 \tag{2.9}$$

where Δ, corresponds to equity portfolio value, weighted by the book value of loans. The RHS gives the residual amount of available capital, when new loans represents a portion, *Ω*, of total portfolio.

Maximizing the expected value of the bank that arises from taking expectations, in Definition 1, while setting $L = \frac{1}{1-\Omega}L^e$, and Δ according to 2.9, allows me to identify the unique relation, between equity and loan prices, that guarantees indifference between those two markets.

Proposition 4. *A bank with a capital ratio above regulatory one, $k > \gamma_s$, will be indifferent between buying equity or loans, if the following condition is true:*

$$E_s(\bar{r_{s'}}) = \sigma - \sigma_l \tag{2.10}$$

Expected value when holding the maximum equity portfolio, with $\Delta = \frac{k}{\gamma_s} - 1$ *is:*

$$V^1 \approx K\left(1 + \beta \frac{E_s\left(\bar{r_{s'}}\right) - \delta\gamma_s}{\gamma_s}\right) - \beta\left(E_s\left(\bar{r_{s'}}\right) + \sigma_l\right) L^e \tag{2.11}$$

The one period expected net return on equity positions should be equal to expected return on loan trading. When returns in the two markets are not equal, I get arbitrage possibilities and bank managers use their excess capital on cheaper assets thus, either $\Omega = 0$ with $\Delta = \frac{k}{\gamma_s} - 1$ (banks only buy equity) or $\Delta = 0$ with $\Omega = \frac{k-\gamma_s}{k}$ (banks only buy loans).

The value function, V^1, set in 2.11 will be higher to that of 2.8 when arbitrage between equity and loan markets is present. Hence, the capital ratio, $\bar{k}$, at which banks become arbitrageurs, $k > \bar{k}$, will be lower. This rises welfare concerns due to potential reductions of new credit to the economy.

When capital ratios are below arbitrage threshold, $k < \bar{k}$, there are two scenarios based on the direction of the inequality $P \lesseqgtr 1$. When market price of loans exceeds par, $P > 1$, and equity is fairly priced, $P_i = K - \sigma L^e$, managers would sell all assets, meaning $\xi = 1$, and no new equity placement will occur (see corollary 1). Banks with capital $k > \sigma$ will survive.

In the case $P < 1$, with equity priced at $P_i = K - \sigma L^e$, managers are indifferent in which asset to sell (until they reach regulatory level), when banks capital makes up for the losses on the loan portfolio but it is below regulatory capital, $\sigma < k < \gamma_s$. Banks with capital above regulation level, $k > \gamma_s$, will not participate in the secondary markets.[29]

Individual equilibrium equity prices, P_i, help identify current equity index price,[30] P_x. Expectations on equity returns are taken under two different probability measures. The statistical measure, $\mathbb{P}$, that describes the fundamental value of the bank,[31]

[29] Here symmetric information on default rates suffice to produce trading in secondary markets in contrast with Greenwood, Hanson, and Stein (2010) who use asymmetric infromation to justify trading when loans are priced under par.

[30] See appendix.

[31] See appendix for a proof

as $E_s(r_{s'}) = \frac{\sigma}{\gamma_s - \sigma}$, and the risk neutral measure, $\mathbb{Q}$, where equity risk premium equals that implied in loan prices and 2.10 holds.

Now I are ready to state the optimal value function in corollary 1.[32]

Corollary 1. *When $P > 1$, banks with sufficient capital ratios, $k > \bar{k^1}$, become arbitrageurs and buy loans, $\Omega = \frac{k-\gamma_s}{k}$, from those with a capital ratio $\bar{k^1} > k > \sigma$, that sell all previous period loans, $\xi = 1$. One period to maturity assets are held by arbitrageurs with a capital to loan ratio $k = \gamma_s$ while banks hold two period to maturity loan portfolios with an optimal capital ratio,$k = k_s^* \geq \gamma_s$. The value of any bank, $\bar{V} = V^*(s|s')$, is:*

$$\bar{V} = \begin{cases} 0 & k < \sigma \\ [k-\sigma] L^e & \bar{k^1} > k > \sigma \\ \left[k\left(1-(1-\beta)\frac{\sigma}{\bar{k^1}}\right) - \beta\sigma\right] L^e & k > \bar{k^1} \end{cases} \tag{2.12}$$

If $P < 1$, $\sigma - \sigma_l \geq E_s(\bar{r_{s'}})$ and $k > \bar{k^2}$, banks become arbitrageurs and buy Ω percent of loans, $\Omega = \frac{k-\gamma_s}{k}$ (with $\Delta = 0$). In case $\gamma_s > k > \sigma$ banks sell ξ percent of loans, $\xi = \frac{\gamma_s - k}{\gamma_s - \sigma}$ (with $\Delta n^b = 0$):

$$\bar{V} = \begin{cases} 0 & k < \sigma \\ \frac{[k-\sigma]}{\gamma_s-\sigma}\gamma_s L^e & \gamma_s > k > \sigma \\ kL^e & \bar{k^2} > k > \gamma_s \\ \left[k\left(1+\beta\frac{\sigma}{\bar{k^2}}\right) - \beta\sigma\right] L^e & k > \bar{k^2} \end{cases} \tag{2.13}$$

If $P < 1$, $E_s(\bar{r_{s'}}) > \sigma - \sigma_l$ and $k > \bar{k^3}$, banks become arbitrageurs and buy Δ percent of equity, $\Delta = \frac{k-\gamma_s}{\gamma_s}$ (with $\Omega = 0$). In case $\gamma_s > k > \sigma$ banks sell Δn^b percent of new

[32] A graphical illustration comparing Repullo and Suarez (2013) value function to ours can be found in Figure A.3.

equity, $\Delta n^b = \frac{\gamma_s - k}{k-\sigma}$ *(with* $\xi = 0$*) and :*

$$\bar{V} = \begin{cases} 0 & k < \sigma \\ \frac{[k-\sigma]}{\gamma_s-\sigma}\gamma_s L^e & \gamma_s > k > \sigma \\ kL^e & \bar{k^3} > k > \gamma_s \\ \left[k + \beta\left(\left(k - \bar{k^3}\right)\left(\frac{\bar{\sigma}}{\bar{k^3}-\gamma_s}\right)\right)\right] L^e & k > \bar{k^3} \end{cases} \tag{2.14}$$

where $\bar{k^i} = k^i\,(s', s)\ \ \forall i \epsilon \{1, 2, 3\}$,$\bar{k^1} = \delta\frac{\sigma}{\bar{\sigma}-\sigma}\gamma_s$, $\bar{k^2} = \gamma_s + \frac{\bar{\sigma}}{\sigma-\bar{\sigma}}\gamma_s$, $\bar{k^3} = \gamma_s + \frac{\bar{\sigma}}{E_s(\bar{r_{s'}})-\delta\gamma_s}\gamma_s$ *and* $\bar{k^2} \geq \bar{k^3}$

2.3.2. Equilibrium in Secondary Markets

I now consider the existence of a capital unconstrained central planner. She optimally allocates capital on a continuum of independent and equally sized asset portfolios, that sum up to one.[33] Interestingly, the optimizing process over capital heterogeneous agents, would result in capital homogeneity at equilibrium. These considerations are used to formulate the joint market clearing conditions for equity and loan markets in proposition 5. Definition 2, rewrites parts of corollary 1, in terms of arbitrage, recapitalization and liquidation thresholds for the default rate.

Definition 2.
i) Arbitrage indifference, $x^{\bar{k}}$*, is:*

$$x^{\bar{k}} = x^{\bar{k}}\,(s|s') = \frac{r_{s'} + k_{s'} - c - \bar{k}^i}{r_{s'} + \lambda - \bar{k}^i}$$

$\bar{k}^i$*, is described in Corollary 1.*

ii) Compulsory recapitalization, x^{γ_s}*, is:*

[33] Assuming rational expectations on prices and capital unconstrained planner would guarantee homegeneity in capital allocation process. See Figure B.1.

$$x^{\gamma_s} = x^{\gamma_s}\left(s|s'\right) = \frac{r_{s'} + k_{s'} - c - \gamma_s}{r_{s'} + \lambda - \gamma_s}$$

iii) Liquidation, x^{σ},is :

$$x^{\sigma} = x^{\sigma}\left(s|s'\right) = \frac{r_{s'} + k_{s'} - c - \sigma}{r_s + \lambda - \sigma}$$

Proposition 5, characterizes the clearing price, P, that sets aggregate demand and aggregate supply equal (see 2.15 and 2.16). Asset demand is a decreasing function with respect to both secondary market prices and regulatory capital, reaching a minimum of zero when $\sigma = \bar{\sigma}$.

The relation between supply and regulatory capital is positive, while supply and loan prices relation is ambiguous. When $\bar{\sigma} < 0$, asset supply and prices are positively related and price increases lead to supply increases. If $\bar{\sigma} > 0$ the relation would be either positive or negative, depending on the size of σ, or of capital scarcity.

If σ is close to its maximum value, $\gamma_{s'}$, the increase in the recapitalization region, $x^{\sigma} - x^{\gamma}$, following a price increase, is bigger than the reduction in individual recapitalization needs, $\frac{\partial \frac{\gamma_s - k}{k - \sigma}}{\partial \sigma} d\sigma < 0$. Then supply and prices positively relates. As price further increases, σ reduces approaching to $\bar{\sigma}$, and the relation is reverted.[34]

Proposition 5. *If $r_{s'} \geq r_s^f = \frac{1}{1-p_s}\left(\delta\gamma_s + c + p_s\lambda\right)$, previous period interest rate, $r_{s'}$, exceeds current period actuarial (fair) interest rate, for one period loans, then the unique price of loans, P, is such that:*

$$\int_0^{x^{\bar{k}}} \left(K - \gamma_s L^e\right) dF_{s'}\left(x\right) = \int_{x^{\bar{k}}}^{x^{\sigma}} \gamma_s L^e dF_{s'}\left(x\right) \tag{2.15}$$

and no new equity is sold, $\Delta n_i^b = 0$.

[34] A graphical illustration of supply and demand can be found in Figure A.4

If $r_{s'} < r^f_s$, the unique value of P leading to market clearing satisfies

$$\int_0^{x^{\bar{k}}} (K - \gamma_{s'} L^e)\, dF_{s'}(x) =$$
$$= \int_{x^{\gamma_s}}^{x^{\sigma}} \left(\gamma_s L^e - \bar{V}\right) dF_{s'}(x) - \gamma_s \int_{x^{\gamma_s}}^{x^{\sigma}} \Delta n_i^b \left(1 - \gamma_s + \sigma\right) \frac{[k-\sigma]}{\gamma_s - \sigma} L^e dF_{s'}(x) \quad (2.16)$$

If $\sigma - \sigma_l \geq E_s\left(\bar{r_{s'}}\right)$, no new equity is sold, $\Delta n_i^b = 0$, and P is the market price of loans. Otherwise recapitalization takes place through equity, with $\Delta n_i^b = \frac{\gamma_s - k}{k - \sigma}$, and P is the equity implied price of loans.

2.3.3. Optimal Capital, k_s^*, and Interest rate, r_s^*

Expressions characterizing the optimal bank value and market clearing conditions (see Eq. 12-16) depend only on previous period capital, $k_{s'}$, and interest rates, $r_{s'}$. Assumption 1 guarantees that when $k > \gamma_s$ the maximization problem solved by bank managers in the determination of the optimal capital ratio, $k^*_{s'}$, is identical and independent of the arrival capital level for all entities, k. In the proof of proposition 5, the reason leading those banks not to increase capital above the arbitrage level, $\bar{k^i}$, is presented.

I could determine the value of a bank that holds a two period to maturity portfolio under state s', $V_{s'}$, by taking expectations on the expressions for $\bar{V}$ set in corollary 1. If the bank decides to hold a capital ratio $k_{s'}$, when the interest rate is $r_{s'}$, its expected present value would be[35]:

$$V_{s'} = V\left(k_{s'}, r_{s'}\right) = \beta \sum_{s=\{h,l\}} q_{s',s} E_{s'} \left(\bar{V} 1_{\left\{\bar{V} \geq 0\right\}}\right) \quad (2.17)$$

[35] See appendix for the expressions of $V_{s'}\left(k_{s'}, r_{s'}\right)$

while the value of $r_{s'}$ is such that:

$$V_{s'} - k_{s'} = 0 \tag{2.18}$$

Bank managers, for the determination of the optimal amount, $k^*_{s'}$, will solve the following problem

The discounted expected value of a bank subject to capital regulation is given by 2.17, managers of existing banks choose the capital ratio, $k^*_{s'}$, to maximize the expected net present value of the bank, $V_{s'}\left(k_{s'}, r^*_{s'}\right) - k_{s'}$, with the interest rate $r^*_{s'}$ given by 2.18, while prices are set via 2.15 and 2.16:[36]

$$\begin{array}{ll} \underset{k_{s'}}{max} & V_{s'}\left(k_{s'}, r_{s'}\right) - k_{s'} \\ s.t: & \quad k_{s'} \geq \gamma_{s'} \end{array}$$

The solution, $\{r^*_{s'}, k^*_{s'}\}$, to this problem is unique, and its implications summarized in corollary 2:

Corollary 2. *The optimal solution for bank managers problem imply that:*

i) $r^*_{s'}$, lies within the set defined by $\left(r^f_l, r^f_h\right)$. Independently of the initial state of the economy, when the economy ends up in state l there is both trading of loans in the secondary loan market and an endogenous upper barrier for the pledgable income a bank could get from its lending activities.

ii) The only stationary equilibrium imply $\lambda + c > k^*_{s'} > \gamma_h - (r^*_{s'} - c)$, and could be interior with $k^*_{s'} > \gamma_{s'}$ or at the corner with $k^*_{s'} = \gamma_{s'}$.

iii) The equilibrium interest rate spread, $r^*_{s'}$ is unique.

iv) If the equilibrium is interior there is a positive probability that existing borrowers suffer refinanciation constraints. There is also a positive probability that banks end up with excess lending capacity.

[36] I assume that the state of the economy is s', and normalized to one the two-periods-to-maturity loan portfolio size, $L_{s'} = 1$.

v) Secondary loan market prices are sufficient statistics of the state of the economy. When the economy is in an expansion, $s' = l$, loan and equity prices are strictly above book value, while when the economy is in a recession, $s' = h$, loan and equity prices are strictly below its book value.

vi) When the solution to optimal capital is interior, there is a positive probability that in state $s' = h$, banks ask for a capital injection from the new generation of shareholders.

vii) When $s' = h$ banks not becoming arbitrageurs will refinance the non traded portion of surviving loans.

Three important implications are extracted from this corollary.

1. Capital inflows from outside the financial sector to the banking system will exist when VaR increases, $\sigma^a < 0$, as in Estrella (2004), but only to banks holding suboptimal capital levels, $k < k^*_{s'}$. This result being an outcome of funding scarcity, rather than *of ad hoc* assumptions on equity liquidity (quadratic costs to new equity sales).
2. First order stochastic dominance of default probabilities, in expansive states, leads to, $r^f_h > r^*_l > r^f_l$. Interest rate, r^*_h, would be lower than r^f_h, managers following a gamble for resurrection pattern. When in recession, $r^f_h > r^*_h > r^*_l$ and refinancing practices are optimal.
3. Asset prices characterize the state of the economy, $P_{s,l} > 1 > P_{s,h}$.[37]

2.3.4. The Bond Market

Bank managers decision on capital is unconstrained due to free access to new capital and bond prices are independent of interest rates to avoid arbitrage. Hence only optimal capital, k^*_s, is affected by bond shares decision, α. When α, changes to a new level α^b, banks could react modifying either capital ratio or interest rates. If optimal capital, k^*_s, remains unchanged and interest rates change from $r^*_s$to $r^{b,*}_s$, perfect competition on primary loan market would imply $V_s\left(k^*_s, r^{b,*}_s|\lambda', c'\right) = V_s\left(k^*_s, r^*_s|\lambda, c\right) =$

[37]In this I make explicit the dependence of loan prices, P, on current and previous state of the economy

$k_s^* L$. However, in this case and with $r_s^{b,*} > r_s^*$, bank managers would have incentives to set $\alpha = 0$ and get profits from liquidity provisioning activities. Otherwise, when $r_s^{b,*} < r_s^*$ they would set $\alpha \to \infty$, to profit from absence of capital regulation on bond market activities. A similar argument would rule out any simultaneous variation on both variables. Hence, the equilibrium interest rate, r_s^*, is constant and independent of bond shares.

Bank managers would first solve for the initial equilibrium pair, $\{k_s^*, r_s^*\}$ when $\alpha = 0$. Secondly, they will find the optimal capital ratios solving problem 2 (see appendix), holding bond prices at the zero profit level:

$$V_s\left(k_s^{b,*}, r_s^*, \lambda', c'\right) = k_s^{b,*} L \tag{2.19}$$

Hence, bond activity affects secondary loan prices and liquidity provisioning through changes in the optimal capital ratio. The risk perception summarized by r_s^*, is unchanged.

2.4. Comparative Statistics

Table 2.1 and Table 2.2, present the variation on equilibrium levels, $\{k_s^*, r_s^*\}$, due to changes in parameter values, $m = \{\lambda, q_{s,h}, \gamma_l, \gamma_h, \delta, c\}$.

When $k_s^* > \gamma_s$, comparative statistics for the *equilibrium loan rate*, r_s^*, are presented in Table 2.1. Those are obtained by differentiating the zero profit condition, 2.19, with respect to each element, m_i, $\frac{dr_s^*}{dm_i}$. The total derivative, $\frac{dV}{dm_i}$, is the sum of the direct effect, $\frac{\partial V}{\partial m_i}$, and the price effect, $\frac{\partial V_{s,i}}{\partial P_{s,i}} \frac{\partial P_{s,i}}{\partial m_i}$. It has opposite sign to $\frac{dr_s^*}{dm_i}$.

Table 2.1.: *Effect of changes in model parameters on the equilibrium loan rate, r_s^**

$m_i =$	λ	$q_{s,h}$	γ_i	δ	c
$\frac{\partial V_{s,i}}{\partial P_{s,i}} \frac{\partial P_{s,i}}{\partial m_i}$	$(-)$	0	$(-)$	$(-)$	$(-)$
$\frac{\partial V}{\partial m_i}$	$(-)$	$(-)$	$(-)$	$(-)$	$(-)$
$\frac{dr_s^*}{dm_i}$	$(+)$	$(+)$	$(+)$	$(+)$	$(+)$

Table 2.1 shows the flexibility of my model in capturing the comparative effects on prices, unlike Repullo and Suarez (2013).[38] A change in any parameter, m_i, other than $q_{s,h}$, leads to a reduction in asset demand and increases aggregate supply[39], damaging bank profitability.

An increase in loss given default, λ, has a direct effect on bank profitability. It will increase financial impairments faced by banks due to borrowers default. Increase in losses due to recapitalization will add up, to further reduce bank value. Changes in financial regulation will go through the same channels of rising financial impairments and reducing arbitrage profits.

Increasing impatience parameter, δ, or non financial expenditures, c, have a similar direct effect. Lending profitability, bank continuation value and arbitrage profits fall. That reduces profits from banking activity, while equilibrium interest rates rise.

Changing $q_{s,h}$ leads to a different bank value through altering the share of expected bank value in the two states. As banks expect ordinary losses in recessions and trading profits on expansions, an increase on $q_{s,h}$ will reduce bank valuation thme pushing equilibrium interest rates up.

When $k_s^* > \gamma_s$, comparative statistics for the optimal capital ratios, k_s^*, are presented in Table 2.2. Those are obtained by differentiating the first order condition obtained in the solution of problem 2, with respect to each element, m_i, $\frac{dk_s^*}{dm_i}$. The total derivative, $\frac{d^2V}{dk_s dm_i}$ is the sum of the interest rate effect, $\left(\frac{\partial^2 V}{\partial k \partial r} + \frac{\partial^2 V}{\partial k \partial P}\frac{\partial P}{\partial r}\right)\frac{\partial r}{\partial m_i}$, the price effect, $\frac{\partial^2 V}{\partial k \partial P}\frac{\partial P}{\partial m_i}$, and the direct effect, $\frac{\partial^2 V}{\partial k \partial m_i}$.

Table 2.2.: *Effect of changes in model parameters on the equilibrium capital ratio, k_s^**

$m_i =$	λ	$q_{s,h}$	γ_i	δ	c
$\frac{\partial^2 V}{\partial k \partial m_i}$	(+)	(+)	(+)	(−)	(+)
$\frac{\partial^2 V}{\partial k \partial P}\frac{\partial P}{\partial m_i}$	(+)	0	(+)	(+)	(+)
$\left(\frac{\partial^2 V}{\partial k \partial r} + \frac{\partial^2 V}{\partial k \partial P}\frac{\partial P}{\partial r}\right)\frac{\partial r}{\partial m_i}$	(−)	(−)	(−)	(−)	(−)
$\frac{dk_s^*}{dm_i}$	(?)	(?)	(?)	(?)	(?)

[38]This model is nested to ours by fixing $P = 1$, and one period interest rates to an exogenome level a

[39]This two effects being the outcome of the reduction on maximum price, $\bar{P}$, and the increase on arbitrage capital threshold, $\bar{k^i}$.

The total effect, $\frac{dk_s^*}{dm_i}$, is ambiguome but partial effects are identified. Changing any parameter, m_i, but $q_{s,h}$, have opposite interest rate and price effects. That is explained by means of sustitivity between interest rate, prices and capital ratio. The impact of parameter changes follow from comparative statistics on equilibrium loan rates.

Increasing loss given default, λ, regulatory capital, γ_i, or transition probabilities, $q_{s,h}$, have a positive direct effect, $\frac{\partial^2 V}{\partial k \partial m_i} > 0$, on optimal capital, k_s^*. This is explained by means of the insurance role of capital. The reduction in banking and arbitrage profits and the increase on financial impairments and probability of facing capital shortages, increase insurance needs of bank managers, hence increasing optimal capital.

Rise in non financial expenditures, c, lead to a positive direct effect $\frac{\partial^2 V}{\partial k \partial m_i} > 0$ on capital. Sustitivity between capital and interest rates, and between those and non financial expenditures are behind this result. Higher c would be equivalent to lower r_s^*. As $\frac{dk_s^*}{dr_s^*} < 0$, and $\frac{\partial^2 V}{\partial k \partial r} < 0$ the result follows.

Negative effect of increases in δ follows the reduction in insurance capacity of capital. While both arbitrage profits and continuation bank value fall, the former dominates.

Next I discuss the calibration of model parameters and perform numerical simulation to compare my model with that presented in Repullo and Suarez (2013).

2.5. Parameter values and Numerical Example

My baseline parametrization of the model is presented in Table 2.3 and discussed below:

Table 2.3.: *Baseline scenario parameter values*

$a =$	λ	$q_{l,h}$	$q_{h,h}$	δ	c	c^e	p_h	p_l	α_i
	45%	20%	64%	4.85%	3.4%	32%	3.6%	1.1%	10%

Transition probabilities from state s to recession, $q_{s,h}$, and average default rates, p_i, are obtained from Repullo and Suarez (2013). A reference value for q_{hh} of 0.64 for generating recession of $\frac{1}{1-0.64} = 2.78$ periods is used while for 5 periods expansion $q_{l,h}$ equals 0.2. Average default rates, p_i, are set to result in a 4% average regulatory capital ratio (as in Basel I). Loss given default, λ, equals 45%, following the Assessment under Basel II Accord for the IRB Standard approach.

Concerned with the wide range of estimates of δ in the literature (see Carlstrom and Fuerst (1997), Van den Heuvel (2008)), $3.16\% < \delta < 5.6\%$ I use the average difference between the yearly returns of the Eurostoxx 600 Banks Index and the yearly average value of the 5 years Itraxx Main for the period 2005-2015, obtaining a value of 4.85%. It is based on the idea that average returns, of a well diversified banking index, include the disadvantage of equity versme debt and the average credit risk of the representative asset portfolio.

The role of the parameter c is to reduce profitability of banking activities to guarantee realistic interest rates. It is calibrated to real non financial unit operating expenditures (taken from the European Consolidated Banking Data[40]). I compute average cost to income ratio of 65%, and 2.6% is the average ratio of income to total assets. The share of retained earnings is found to be around 50%. Non financial operating expenditures to total assets is then obtained[41] as $\frac{0.65X0.026}{0.5} = 3.38\%$.

Parameter c^e accounts for both non-financial costs on equity holdings and regulatory disadvantage of equity versme loans. It will affect the market to book value ratio, and is calibrated at a 32% level to render values in the 65% to 180% range. This range is obtained using minimum and maximum values of the average market to book value ratio of Eurostoxx 600 Banks Index over the periods 2002-2007, 2008-2009, 2009-2011 and 2011-2014. [42]

To parametrize α, I calculate an upper bound of 15% using the average ratio of Total Debt Instruments over Total Assets over the period 2007-2013 from European Consolidated Banking Database, setting a conservative reference value of 10%.

[40] See http://sdw.ecb.europa.eu/browse.do?node=71390

[41] I divide by the ratio of retained earnings to normalize the effect of cost, in terms of its real impact on capital

[42] These periods have been identified by Euro Area Business Cycle Dating Commitee as expansions and recessions. See http://www.cepr.org/content/euro-area-business-cycle-dating-committee for further details

2.5.1. Numerical Example

Numerical results under my baseline parametrization are presented in this section. First I define refinancing-rationing, $RR = RR(s|s')$, then results concerning equilibrium loan rates, capital ratios, bankruptcy costs and refinancing-rationing are displayed in Table 2.4, along with a brief description of those. Finally, market related results are shown in Table 2.5.

Refinancing-rationing extends the concept of credit rationing introduced in Repullo and Suarez (2013), by taking into account legacy loans from previome period credit activities and trading incentives. RR amount is normalized, by a $\frac{1}{2}$ factor, to take into account the additional mass of newly incorporated entrepreneurs for each period. It is calculated as the expected reduction in the stock of loans following non refinanciation (net of liquidity provisioning activities), because of bank nationalization or trading decisions.

$$RR = \begin{cases} \frac{1}{2}\left(PL_{s'} - NC_{s',s}\right), & P > 1 \\ \frac{1}{2}\left(PL_{s'} - NC_{s',s} + S - NA\right), & \sigma - \sigma_l > E_s\left(\bar{r_{s'}}\right) \\ \frac{1}{2}\left(PL_{s'} - NC_{s',s} - NA\right), & Otherwise \end{cases} \tag{2.20}$$

with $NA = \int_{x^{\bar{k}}}^{x^{\sigma}} L^e dF_{s'}(x)$, and $S = \int_{x^{\gamma_s}}^{x^{\sigma}} \left(1 - \frac{k_s - \sigma}{\gamma_s - \sigma}\right) L^e dF_{s'}(x)$.

The first term, $PL_{s'} = 1 - p_{s'}$, represent next period mass of performing loans. $NC_{s',s}$, the excess lending capacity or new credit to the economy[43], S the aggregate supply of loans for trading, and NA the mass of loans in hands of non nationalized banks or arbitrageurs.

[43] Its expression could be found in the appendix

2.5.1.1. Results on banking variables

Table 2.4.: *Numerical results on banking variables*

	$\mathbb{Q}$ Measure	$\mathbb{P}$ measure	RS [2013]
r_h^*	1.7%	1.7%	3.3%
r_l^*	0.73%	0.69%	1.3%
k_h^*	6.09%	6.09%	6.70%
k_l^*	6.81%	5.19%	6.90%
$k_h^* - \gamma_h$	60bps	60bps	120bps
$k_l^* - \gamma_l$	365bps	203bps	380bps
Bankruptcy Probabilities			
State: h after h	2.51%	2.51%	2.25%
State: l after h	0.87%	0.87%	0.16%
State: h after l	2.41%	0.82%	2.25%
State: l after l	0.09%	0.25º%	0.16%
Unconditional	1.04%	0.919%	0.9%
Bankruptcy Cost			
State: h after h	2bps	2bps	
State: l after h	1bp	1bp	
State: h after l	-6bps	0.6bps	
State: l after l	0.2bps	0.4bps	
Unconditional	-0.1bps	0.8bps	
Liquidation level			
State: h after h	1.28%	1.28%	0%
State: l after h	-1.15%	-1.15%	0%
State: h after l	5.05%	1.84%	0%
State: l after l	-0.1%	-0.06%	0%
Unconditional	0.74%	0.35%	0%
Refinancing/credit Rationing			
State: h after h	5.58%	7.58%	12.4%
State: l after h	25.77%	18.59%	5.3%
State: h after l	-7.08%	0.36%	12.6%
State: l after l	24.57%	31.36%	0.9%

The first panel of Table 2.4 presents equilibrium loan rates, optimal capital and capital buffers for my model, with and without imposing absence of arbitrage opportunities between equity and loan markets, like Repullo and Suarez (2013). In panel 2, state contingent bankruptcy probability and its unconditional mean are displayed.[44] Panel 3 illustrates bankruptcy costs faced by the government on their role as deposit insurer, panel 4 the optimal liquidation threshold of banks and, panel 5 results on rationing.

Loan rates are always greater when arbitrage between loan and equity markets is absent (under $\mathbb{Q}$ measure). When arbitrage is present ($\mathbb{P}$ measure), banks recapitalization possibilities increase, following the increase in recapitalization power of capital. This reduces costs of bankruptcy, and insurance needs, while increasing arbitrage profits and the return on banking activities. Both effects considered, equilibrium loan rates and optimal capital ratios fall, while bankruptcy costs for the government increase. The increase in bankruptcy costs follow the reduction in banks liquidation threshold, σ. My calibration suggest a fall in capital buffers of 160 bps, when arbitrage between equity and loans market is endogenized (column 2). This value is very close to the preservation buffer under Basel III Accord.[45]

When arbitrage is absent, capital buffers on expansions, are similar to those in Repullo and Suarez (2013). Capital buffers on recessions, or when arbitrage is endogenized, along with interest rates, exhibit significant differences. The discrepancy in interest rates is justified by both differences in the value assigned to parameter δ, and on the selection of optimal capital buffers. Calibration of the δ parameter is motivated by a different perception on the remuneration of capital. While I assume a value for δ of 4.85%, corresponding to a fair remuneration of Tier 1 Capital, in Repullo and Suarez (2013) that is set to 8%, to guarantee a fair remuneration of both, Tier 1 and Tier 2 capital. The reduction in capital buffers, on recessions, comes directly from the cyclical nature of arbitrage profits. Repullo and Suarez (2013) justify arbitrage profits via relational lending, variations on regulatory capital inducing cyclicality on those. In contrast, in my model, those profits exhibit a lower cyclical pattern. Capital exuberance on the transition to expansionary states,

[44] Results presented for RS model correspond to bankruptcy probabilities for first period banks.

[45] Preservation buffer rules out moral hazard problems and reduce deposit insurance related costs for governments.

leading a fall on those. The fall in capital buffers, when arbitrage between equity and loans is present, comes directly from the reduction in the bankruptcy region which relaxes capital demand for insurance purposes.

Partial commitment on loans to entrepreneurs, assumed in Repullo and Suarez (2013), lead results on credit rationing. Banks capacity to re-balance loan portfolios when capital shortages are present and without incurring in losses, reduce liquidation thresholds, bumping up bank liquidity provisioning activities. Results on refinancing rationing, in my model, reflect the existence of legacy portfolios and arbitrage patterns across banks. Those lead to dependence between actual and previome period credit activity, implying the existence of lags between economy state and credit growth, better observed in transition periods. The reduction in arbitrage threshold, $\bar{k^i}$, when arbitrage opportunities between equity and loan markets are present, reduce volatility of credit activities on recessions along with banks liquidity provisioning[46], while volatility rises on expansions.

2.5.1.2. Results on market variables

The first column of Table 2.5 present results for market variables when absence of arbitrage is imposed, second column accounting for the endogeneization of those. Panel 1 presents loan clean prices, making those comparable with bond prices displayed on panel 2. Comparability among those allow me to interpret the difference between loan and bond prices as a direct measure of regulatory costs. When arbitrage opportunities between equity and credit are dependent on capital constraints, a proper functioning of secondary loan market is not guaranteed, and loan prices are implied from equity valuation. Loan prices are directly derived when arbitrage opportunities are absent. Figure 2.1 and Figure 2.2 illustrate the effects of changes on parameter α on bond prices and optimal capital. In panel 3, the ratio of market to book value of capital for an optimally capitalized bank is presented.

Market to book value ratios are higher when arbitrage opportunities between equity and loan markets are endogenized, higher differences observed in the transition from

[46] Under my baseline scenario, liquidity provisioning activities in the transition from expansion to recession collapse

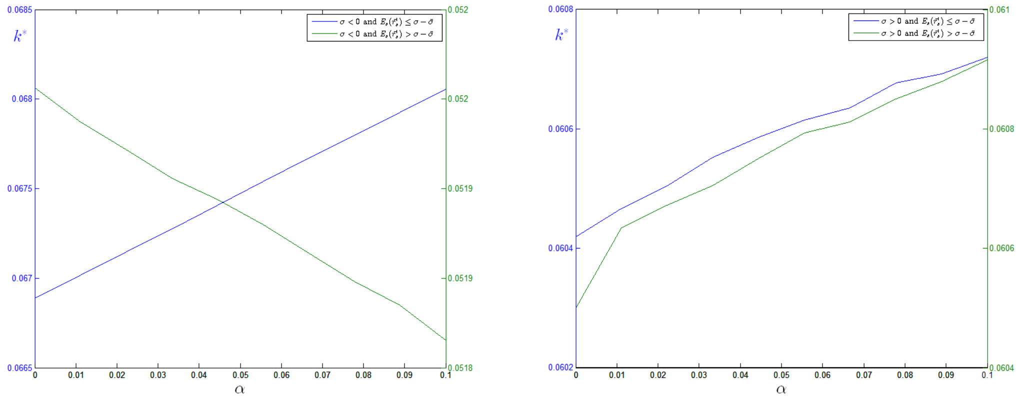
expansions to recessions. This relates with results on refinancing rationing and capital scarcity. Increase in trading profits reduce the arbitrage threshold, $\bar{k}^3$, and capital scarcity, while bumping implied asset prices up. When equity and loan prices are aligned, strong discount on loan prices in the transition from an expansion to a recession provide theoretical support to empirical evidence of high discounts on book valuation, following IPOs, on recent crises.

Comparing homogeneous loan and bond prices allow me to quantify the effect of regulatory costs. When arbitrage opportunities are absent and on recessions, capital constraints, lead to significant differences between bond and loan prices. The endogeneization of arbitrage bumps loan prices up when capital is more scarce (in the transition from expansion to recession).

Table 2.5.: *Market Prices and Market to Book value of capital*

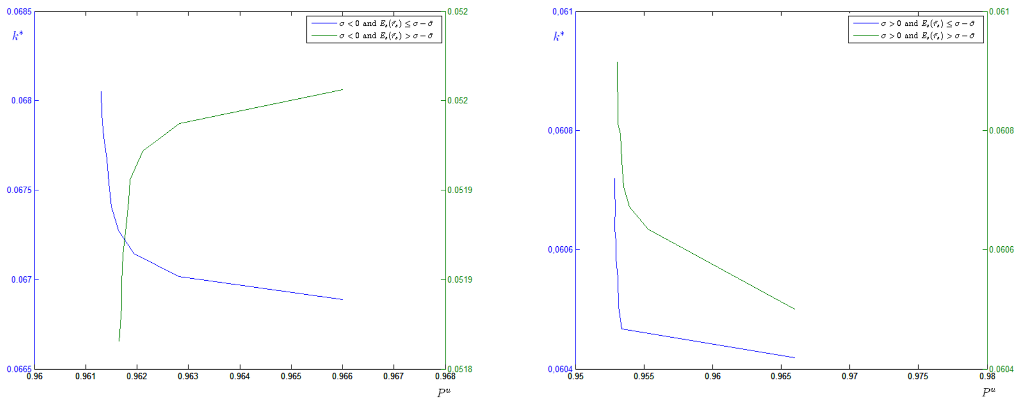
	$\mathbb{Q}$ Measure	$\mathbb{P}$ measure
Loan Prices, P		
State: h after h	93.91%	93.89%
State: l after h	96.21%	96.21%
State: h after l	91.18%	94.30%
State: l after l	96.13%	96.12%
Bond Prices, B'		
State: h	95.29%	95.30%
State: l	96.13%	96.16%
Market to book value of capital, $\frac{k^*_{s'} - \sigma}{k^*_{s'}}$		
State: h after h	78.98%	78.98%
State: l after h	116.9%	122.2%
State: h after l	17.07%	69.78%
State: l after l	101.46%	101.15%

__Figure 2.1.:__ Relation between bond portfolio size and optimal capital



The relation between bond shares and prices is inverse due to price-quantity substitution effects, irrespectively of the model considered. However, this is not the case for the relation between capital ratios and bond prices. When arbitrage between equity and loans is exogenous, Figure 2.1 illustrate the positive relation between bond shares and capital due to insurance needs. This relation inverts when arbitrage is endogenized, following the increase of recapitalization power of capital and arbitrage profits. The relation between bond prices and optimal capital illustrated on Figure 2.2 is explained by similar means.

__Figure 2.2.:__ Optimal capital and Bond Prices



2.6. Welfare Analysis

Equilibrium conditions characterized in 2.18 and 2.19, imply no welfare effects on banks shareholders, (see Repullo and Suarez (2013)). I can therefore focme on welfare implications[47], following modifications of loan flows to the economy [48] and costs faced by governments on their role of deposit insurers. State contingent social welfare, $W_{s,s'} = W(s'|s)$, is:

$$W_{s,s'} = (NC_{s,s'} - NR_{s,s'} - R_{s,s'})(\mu - r^*_{s'}) - \omega BR_{s,s'} \tag{2.21}$$

The first term, $NC_{s,s'}$, represents next period expected mass of new loans to the economy, $NR_{s,s'}$ the (expected) mass of non refinanced loans. $R_{s,s'}$ is the reduction on new loans due to capital injections from new shareholders, then, $BR_{s,s'}$ the cost faced by governments due to their role as deposit insurers[49]. Parameter $\omega \geq 1$, represents, in a reduced form, governments aversion (or financial constraint) to assume losses coming from financial sector. For the two models analyzed in previome section, a welfare analysis on the variation of that parameter over the 1 to 100 range is presented. Last, μ was defined, on previome sections, as the total return including social benefits of entrepreneurial activities. Following Repullo and Suarez (2013) I set a reference value for that parameter of 8%, while my results hold for different parametrization.

Total social welfare, W, is then obtained by aggregation, for all states of the economy, of each state contingent social welfare measure, $W_{s,s'}$, weighted by its corresponding ergodic probability:

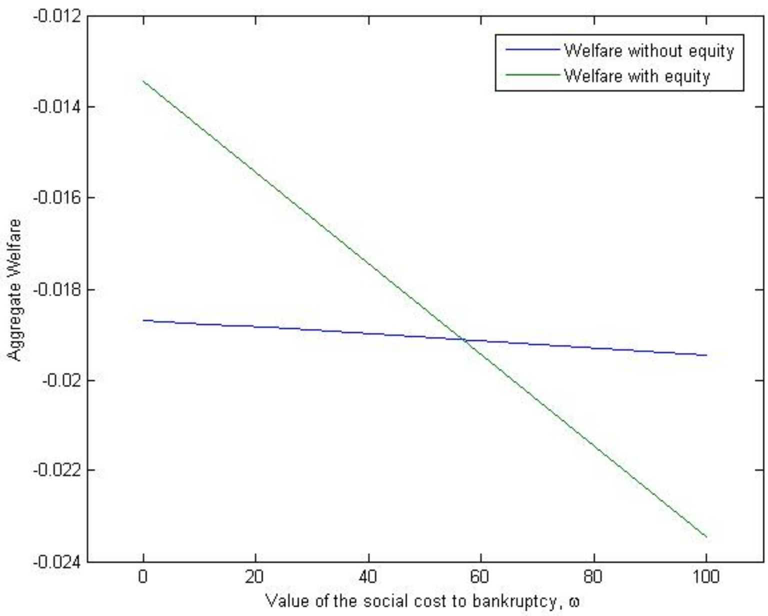
$$W = z_l (q_{lh} W_{lh} + (1 - q_{lh}) W_{ll}) + (1 - z_l)((1 - q_{hh}) W_{hl} + q_{hh} W_{hh}) \tag{2.22}$$

[47]The numerical exercise is performed under my baseline parametrization.
[48]Loan flows are modified either by non refinancing or recapitalization through capital injections.
[49]The formal expression of those variables can be found in appendix

with z_l the unconditional probability of an expansion.[50]

Figure 2.3 illustrate welfare effects of changes on risk aversion parameter, ω. It follows, from the specification of $W_{s,s'}$, that increases on risk aversion will lead to reductions on welfare, with independence of arbitrage opportunities between equity and loan markets. However, my results suggest that the size of welfare variations will be contingent on banks capacity to obtain profits from equity trading.

Figure 2.3.: *Short selling and Social Costs of Bankruptcy*



When risk aversion parameter is low, social welfare improves due to the endogeneization of arbitrage opportunities on equity, as in Acharya, Shin, and Yorulmazer (2013). Improvements come from the increase in the provision of new credit and the fall on both recapitalization needs and fewer refinanced loans. A fall in optimal capital shifts up liquidity provisioning and reduce recapitalization needs. Drops

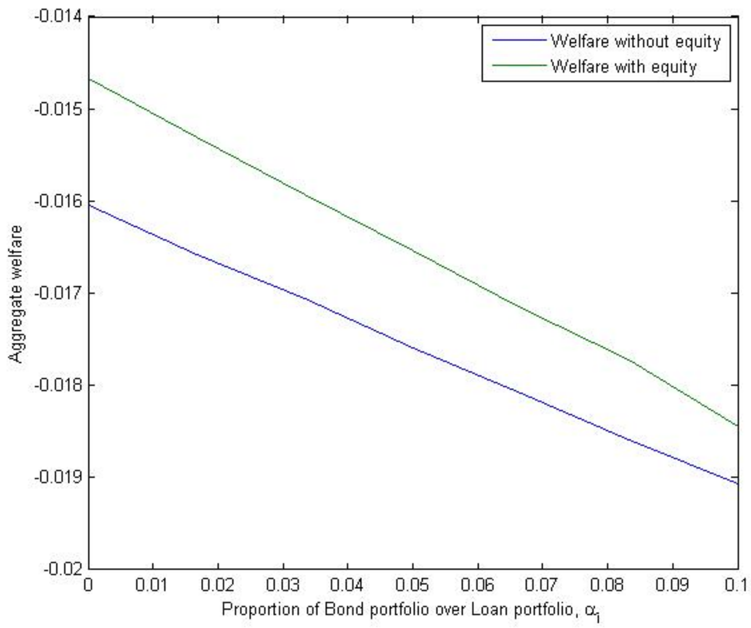
[50]Under my baseline parametrization $z_l = 64.29\%$.

in arbitrage, $\bar{k^3}$, and liquidation threshold, σ, lower the mass of refinanced loans and pushes up bankruptcy costs. Increasing risk aversion of governments, ω, erase welfare gains from liquidity provisioning, elevating the weight of bankruptcy costs. These results are in line with short selling literature (see Bris, Goetzmann, and Zhu (2007)) and against the regulatory perception blaming short sellers as speculators (see Goldstein and Guembel (2008)).

Price inefficiencies due to short selling frictions post an additional theoretical justification to benefits of short selling activities on financial stocks. Underpricing of stocks reduce moral hazard problems of bank managers, increasing efficiency of capital ratio regulation.

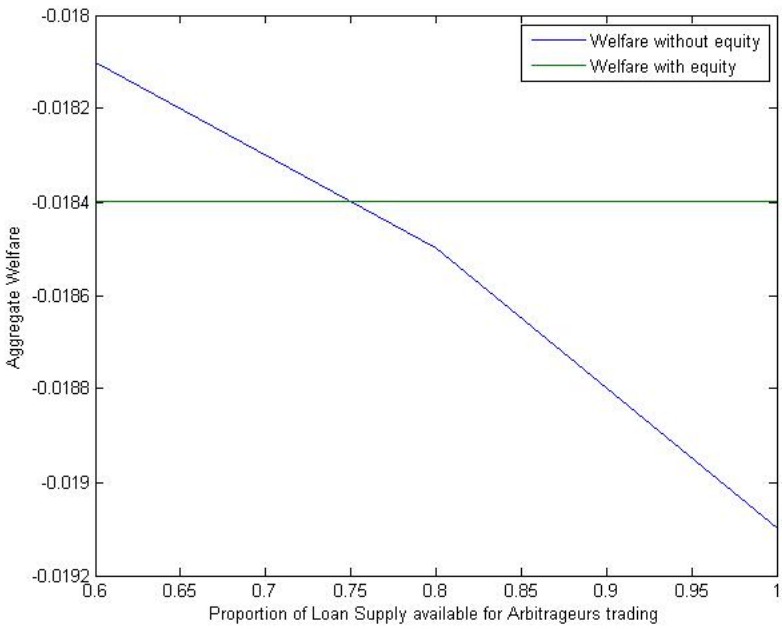
Figure 2.4 illustrate welfare effects, when $\omega = 1$, arising from modifications on equilibrium bond portfolio shares, α, due to market actions from monetary authorities (ECB).

Figure 2.4.: *Effect of changes in the composition of the portfolio on Welfare*



Bond purchases reduce bond shares on bank portfolios and lead to welfare increases. This is true independently of the endogeneity of arbitrage between markets. On expansions, when arbitrage is endogenous, falling bond shares elevate bond prices and optimal capital. This relation is inverted in recessions and when arbitrage is absent. Loan trade activity and loan prices along with refinancing possibilities augment as capital needs drop now, in turn pushing bankruptcy costs higher. Welfare effects are positive on aggregate. Increasing optimal capital on expansions, when arbitrage is endogenized, lead to direct reductions on liquidity provisioning activities and it is fully compensated by the reduction on bankruptcy costs. Higher loan prices and fewer arbitrageurs ($\bar{k}^1$ rises) result in lower bankruptcy costs .

Figure 2.5.: *Welfare Effects of an Intervention in Loan Markets leading to the reduction in Supply*



Central banks can opt for buying loans in secondary markets, instead of bond purchasing. They execute via either direct trading of loans or through acquisition of securitizations, irrelevant to my model, as long as synthetic securitizations are considered. Loan acquisitions are modeled as a reduction on loan supply in recessions, S in 2.20, so that final loan supply is dS with $d \leq 1$. I decide not to consider the acquisition of equity because of legislation forbid direct financing of commercial banks from Central Banks. In Figure 2.5 I show the impact on welfare of such execution, for values of d in the 60% to 100% range.

While welfare effects of loan and bond purchases are similar when arbitrage between markets is absent, capital scarcity drives to neutral effects of such action, even for reductions on loan supply by up to 40%.

2.7. Conclusion

I have presented a model for the determination of bank capital within an infinitely lived economy with two aggregate default states (identified as expansions and recessions). Banks have access to equity markets and two different credit assets (loans and bonds), and are subject to regulatory requirements affecting their leverage capacity. Credit assets differ on their regulatory treatment, maturity and trade-ability. Using this set up I explored the implications of capital regulation on asset prices, regulatory arbitrage and maturity transformation role of banks. My model differs from previome studies as I relax ad hoc assumptions on liquidity and informational asymmetries, see Repullo and Suarez (2013), Estrella (2004) or Peura and Keppo (2006). Instead I employed an endogenome profit generating mechanism, based on the concept of limit arbitrage presented in Kondor (2009). Within this framework, new optimal trading and recapitalization rules are derived.

My model highlights the role of equity as the preferred recapitalization mechanism on recessions for both banks complying with capital regulation, $k > \gamma$, and undercapitalized banks of highly capital constrained economies. Under expansions, asset sales are preferred. The characterization of trading and recapitalization rules permits me the derivation of an optimal value function, arising from bank manager maximization problem, which then helps to determine optimal bank capital and analyze its relations with price formation. In this context, capital buffers may arise optimally to avoid potential dilution of shareholders, deleverage costs and bankruptcy, while endogenously kept at a low level to guarantee the existence of profits from arbitrage opportunities. When the economy is at recessive states, my results point towards the optimality of refinanciation processes (asset maturity increases). Capital exuberance on expansions lead to non refinanciation of existing positions and to increases on credit provision in the economy which would result on reductions of overall asset maturity.

New results on pricing effects of capital decisions are discussed at a cost of increased complexity in the model coming from the introduction of markets. While perfect competition on primary loan and bond markets drives results in interest rate selection and liquidity provision activities. Scarcity of capital destined to arbitrage activities lead results on secondary market prices. When capital scarcity is severe, arbitrage between equity and loan markets arises. Arbitrage between equity and loan markets reduce the volatility of loan prices and the interest on liquidity provisioning activities, keeping unchanged bond pricing. I find that scarcity also reduces bank resilience coming from the fall in the precautionary impact of capital regulation. My model indicates higher profitability of arbitrageurs trading activities, in this case. The effect of introducing bond markets on banking variables is mixed. Bond portfolios reduce non financial expenditures and private lending while overall risk rises, see Mergaerts, Vander Vennet, et al. (2015). Bond size portfolio and equilibrium prices are, as expected, inversely related due to price-quantity substitution. However, the relation between bond prices and capital depend on the degree of integration between equity and loan markets. When capital scarcity is high, bond portfolios further reduce the resilience of the banking system. This is due to the reduction of optimal capital and lower levels of liquidity provisioning coming from regulatory arbitrage. Otherwise, bond portfolios increase the resilience of the banking system increasing optimal capital.

Following the theoretical discussion of the model, a numerical example is presented. This example is based on a similar calibration to that presented on Repullo and Suarez (2013) for comparison. When arbitrage between loan and equity markets, due to capital scarcity, is present, pro-cyclicality (reduction of capital buffers on expansions) is reduced. In that case, volatility of optimal capital (and thme risk) increases along with costs faced by governments due to their insurance role of deposits. The state of economy conditions liquidity provisioning decisions, while its importance increases with arbitrage between markets. Under my conservative calibration, a collapse in both secondary loan trading and liquidity provisioning will follow the transition from expansive to recessive states.

The introduction of market prices as a crucial decision variable for banks allow me to analyze welfare effects arising from market actions of monetary authorities. This constitutes one of the biggest advantages of my model. My numerical results point towards the convenience of bond purchase programs like the ones performed under quantitative expansions. Bond purchases increase the provision of private loans to the economy while reducing the amount of additional capital required by bank managers for its recapitalization. Also, evidence in favor of a more tighten capital regulation is suggested as a way to reduce bankruptcy costs faced by governments. This costs would be further reduced through an increase in the market monitoring role of central authorities aimed to guarantee the correct pricing of risks (e.g. the convergence between loan and equity prices). The increase in market monitoring will rise welfare effects from secondary loan market acquisitions from central authorities which will otherwise be non effective.

A. Figures

Figure A.1.: *Differences between exact and approximated Maximum Price* $\left(P^p - \bar{P}\right)$

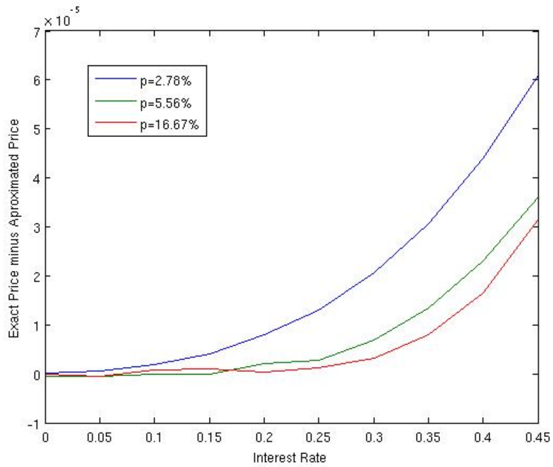


Figure A.2.: *Difference between Exact and Approximated Loan Prices* $\tilde{P} - P$

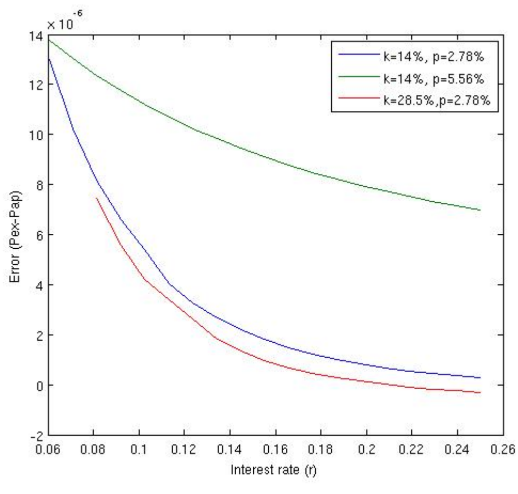


Figure A.3.: *Comparison of my value function $\bar{V}$ with Repullo and Suarez (2013)*

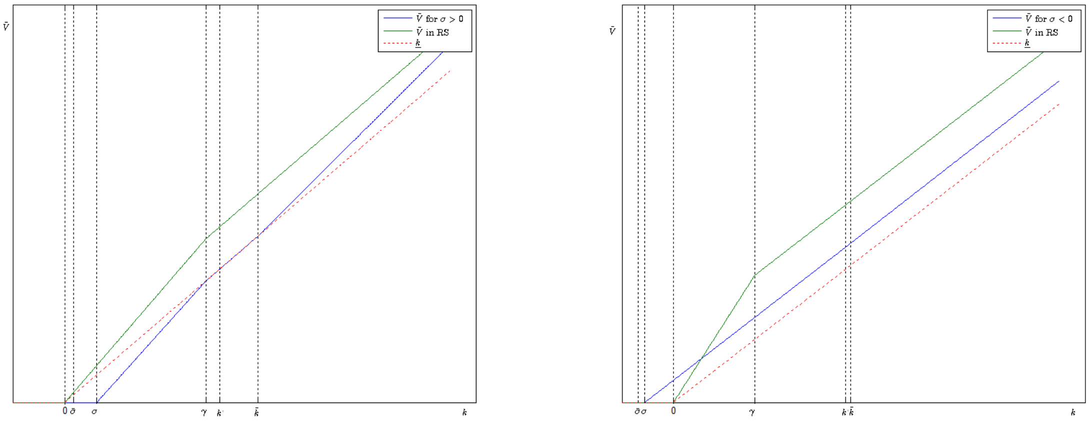
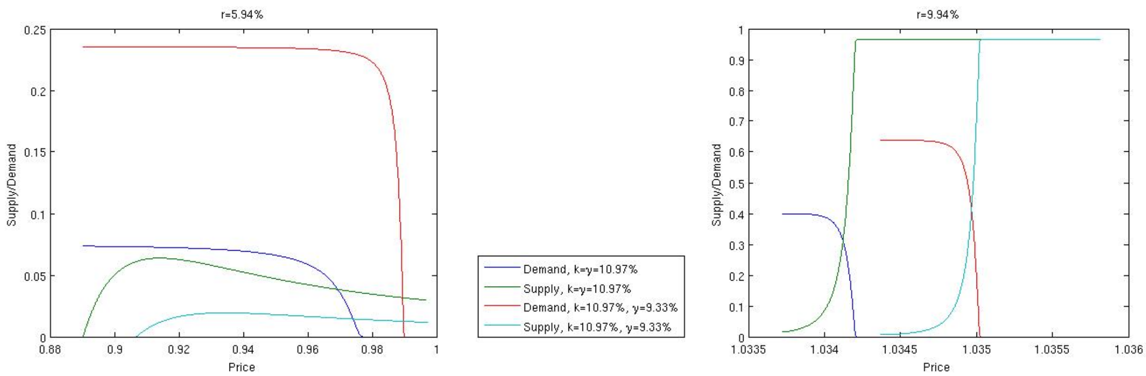


Figure A.4.: *Characterization of Aggregate Supply and Demand*



B. Mathematical Proofs

Proof of Proposition 1. Consider the integral: $\pi_s\left(x\left(P\right)\right) = \beta\left(r_{s'} + \lambda\right) \int_0^{x(P)} F_s\left(x\right) dx$ where $x(P) = \frac{r_{s'}+\gamma_s-c+1-P}{r_{s'}+\lambda}$. I could rewrite that as:

$$\pi_s\left(x\left(P\right)\right) = \beta\left(r_{s'} + \lambda\right)\left(1 - \int_{x(P)}^{1} F_s\left(x\right) dx - p_s\right)$$

Then call $H\left(x\right) = \int_{x(P)}^{1} F_s\left(x\right) dx$, under a Taylor expansion around $x = 1$, I could write:

$$H\left(x\right) = 0 + 1 \cdot \left(1 - x\left(P\right)\right) + \frac{1}{2}\frac{a}{c}\frac{\phi\left(\frac{a\Phi^{-1}(1)-b}{c}\right)}{\phi\left(\Phi^{-1}\left(1\right)\right)}\left(1 - x\left(P\right)\right)^2 + O\left(x\right)$$

where $a = \sqrt{1-\rho}$, $b = \Phi^{-1}\left(p\right)$, $c = \sqrt{\rho}$. If $\rho \leq \frac{1}{2}$ both $\frac{a}{c}\frac{\phi\left(\frac{a\Phi^{-1}(1)-b}{c}\right)}{\phi(\Phi^{-1}(1))}$ and $O\left(x\right)$ converge to zero when $x = 1$ so that $H\left(x\right)$ could be approximated by:

$$H\left(x\right) \approx \left(1 - x\left(P\right)\right)$$

Consequently:

$$\pi_s\left(x\left(P\right)\right) = \beta\left(r_{s'} + \lambda\right)\left(1 - \left(1 - x\left(P\right)\right) - p_s\right) = \beta\left(r_{s'} + \lambda\right)\left(x\left(P\right) - p_s\right)$$

Hence:

$$\begin{aligned}
&\pi_s\left(x\left(P\right)\right) - \gamma_s = 0 \Longleftrightarrow \beta\left(r_{s'} + \lambda\right)\left(x\left(P\right) - p\right) - \gamma_s = 0 \Longleftrightarrow \\
&\Longleftrightarrow \beta\left(r_{s'} + \gamma_s - c + 1 - P - p_s\left(r_{s'} + \lambda\right)\right) = \gamma_s \\
&\qquad\qquad \Longleftrightarrow \bar{P} = \left(1 + r_{s'} - c - p_s\left(r_{s'} + \lambda\right)\right) - \delta\gamma_s
\end{aligned}$$

Also:

$$\sigma^a = I\left(x\left(1\right)\right) - \gamma_s = \pi_s\left(x\left(1\right)\right) - \pi_s\left(x\left(\bar{P}\right)\right) =$$
$$= \beta\left(r_{s'} + \lambda\right)\left(\left(1 - x\left(1\right)\right) - \left(1 - x\left(\bar{P}\right)\right)\right) = -\beta\bar{\sigma}$$

This approximation is also used in Repullo and Suarez (2004) □

Proof of Proposition 2. Let me start by characterizing the value of the bank (abstracting from the possibility of buying an equity portfolio), contingent on its trading/liquidity provisioning decision, under Definition 1:

$$\bar{V} = V_{s',s} = \begin{cases} V^1 = \frac{1}{1-\Omega}\left(\beta\left(r_{s'}+\lambda\right)\int_0^{\frac{r_{s'}+(1-\Omega)k-c+\Omega\sigma}{r_{s'}+\lambda}} F_s\left(x\right)dx\right)L^e & with\ \Omega > 0 \\ V^0 = \left(k-\sigma\right)L^e & with\ \xi = 1 \\ \hat{V}^1 = \left(\beta\left(r_{s'}+\lambda\right)\int_0^{\frac{r_{s'}+k-c}{r_{s'}+\lambda}} F_s\left(x\right)dx\right)L^e & with\ \alpha = \Omega = \xi = \omega = 0 \\ V^2 = kL^e & with\ \alpha > 0\ or\ \omega > 0 \end{cases}$$

V^1 denotes the value of a bank that decides to buy loans in the market (it could be easily proven that in this case $\Omega = \frac{k-\gamma_s}{k}$) and become an arbitrageur, V^0 is the value of the bank if it is liquidated through asset sales, $\hat{V}^1$ is the value of the bank if it decides not to do anything so that it is liquidated in the very next date and V^2 is the value of the bank if it decides to refinance its loan portfolio and/or provide new loans given the perfect competition environment.

First, when $P > 1$ it is clear that $V^0 > \hat{V}^1$ and $V^0 > V^2$, hence banks decision could oscillate between full deleverage and full leverage. Indifference takes place whenever:

$$\frac{1}{1-\Omega}\left(\beta\left(r_{s'}+\lambda\right)\int_0^{\frac{r_{s'}+(1-\Omega)k-c+\Omega\sigma}{r_{s'}+\lambda}} F_s\left(x\right)dx\right) = \left(k-\sigma\right)$$

Making use of the proof of previome proposition and $\Omega = \frac{k-\gamma_s}{k}$, one could rewrite above expression as:

$$\begin{aligned}
\frac{k}{\gamma_s}\beta\left(r_{s'}+\gamma_s-c+\sigma\left(1-\frac{\gamma_s}{k}\right)-p_s\left(r_{s'}+\lambda\right)\right) &= (k-\sigma)\Longleftrightarrow \\
\Longleftrightarrow \beta\left(r_{s'}+\gamma_s-c+\sigma\left(1-\frac{\gamma_s}{k}\right)-p_s\left(r_{s'}+\lambda\right)\right) &= \gamma_s-\sigma\frac{\gamma_s}{k}\Longleftrightarrow \\
\bar{P} &= P-\delta\sigma\frac{\gamma_s}{k}
\end{aligned}$$

Second, when $P \leq 1$ it is clear that $V^2 > V^0$ and also $V^2 > \hat{V}^1$. Therefore, banks decision oscillate between refinancing/liquidity provisioning and full leverage. Indifference happens whenever:

$$\beta\left(r_{s'}+\gamma_s-c+\sigma\left(1-\frac{\gamma_s}{k}\right)-p_s\left(r_{s'}+\lambda\right)\right)=\gamma_s$$

which given Proposition 1 and the definition of $\bar{P}$ imply:

$$\sigma\left(1-\frac{\gamma_s}{k}\right)=1-\bar{P}\Longleftrightarrow\bar{P}=P+\sigma\frac{\gamma_s}{k}$$

and completes the proof. □

Proof of Proposition 3. Trivially, from the specification of the value function when banks decide to become arbitrageurs, V^1, in previome proposition and making use of the proof of Proposition 1, one could write:

$$\begin{aligned}
&V^1=\frac{k}{\gamma_s}\beta\left(r_{s'}+\gamma_s-c+\sigma\left(1-\frac{\gamma_s}{k}\right)-p_s\left(r_{s'}+\lambda\right)\right)L^e\Rightarrow \\
&\Longleftrightarrow V^1=\frac{K}{\gamma_s}\beta\left(r_{s'}+\gamma_s-c+\sigma-p_s\left(r_{s'}+\lambda\right)\right)L^e-\beta\sigma L^e\Longleftrightarrow \\
&\Longleftrightarrow V^1=\frac{K}{\gamma_s}\beta\left(\sigma-\bar{\sigma}+\frac{1}{\beta}\gamma_s\right)-\beta\sigma L^e
\end{aligned}$$

Expression equivalent to the one shown in text □

Proof of Proposition 4. Let me first state the problem solved by bank managers when $\bar{P} < 1$.

Under Definition 1, the next period capital of a bank that decides to buy assets in the market (and become an arbitrageur) will be characterized, with a simplifying abuse of notation, by:

$$K = \frac{1}{1-\Omega}\left(r_{s'} + (1-\Omega)\,k_{s'} + \Omega\sigma + \Delta\bar{r_s} - c - x\,(r_{s'} + \lambda)\right)L^e$$

where $\Delta = \left((1-\Omega)\,\frac{k}{\gamma_{s'}} - 1\right)$ for the regulatory restriction to be satisfied. Therefore, the expected value of the bank would be:

$$\bar{V} = E\left(K1_{\{K>0\}}\right) = \frac{1}{1-\Omega}L^e\beta\,(r_{s'} + \lambda)\int_0^{\frac{r_{s'}+(1-\Omega)k+\Omega\sigma+\Delta\bar{r_s}-c}{(r_{s'}+\lambda)}} F_{s'}\,(x)\,dx$$

Which under Proposition 1 becomes:

$$\bar{V} = E\left(K1_{\{K>0\}}\right) = \frac{1}{1-\Omega}\beta\left(\sigma - \bar{\sigma} + \delta\gamma_s + (1-\Omega)\,(k-\sigma) + E\,(\bar{r_s})\left(\frac{(1-\Omega)\,k}{\gamma_s} - 1\right)\right) \quad \text{(A.1)}$$

The problem solved by bank managers is:

$$\begin{aligned}
&\underset{\Omega}{max} \quad E_{s'}\left(K1_{\{K>0\}}\right)\\
&s.t \qquad \Omega \leq \tfrac{k-\gamma_s}{k}\\
&\qquad\quad E_{s'}\left(K1_{\{K>0\}}\right) \quad \geq K'
\end{aligned} \quad \text{(A.2)}$$

The first order condition of this problem implies:

$$F.O.C.: \beta\,(\sigma - \bar{\sigma} + \delta\gamma_s - E\,(\bar{r_s})) = 0$$

Moreover, the incentive compatibility constraint set in A.2 implies that banks only buy assets if $k \geq \frac{\sigma}{\sigma-\bar{\sigma}}\gamma_s$ with $(\sigma - \sigma_l - E_s\,(\bar{r_s})) \geq 0$ or if $(\sigma - \sigma_l - E_s\,(\bar{r_s})) < 0$ with $k \geq \gamma_s + \frac{\bar{\sigma}}{E(\bar{r_s})-\delta\gamma_s}\gamma_s$. Those are the expressions provided in Corollary 1 for $\bar{k}^2$ and $\bar{k}^3$. □

Proof of Corollary 1. The expected value of an under-capitalized bank, for existing shareholders when the bank decides to refinance their loan portfolio is, making use of Assumptions 1 and 2:

$$\bar{V} = \frac{1}{1 + \Delta n_i^n} \left(K - \sigma \xi L^e + \Delta n_i^n \bar{P}_i \right) \tag{A.3}$$

Given that the bank has to comply with capital regulation, bank manager's decision will be the result of the maximization problem:

$$\max_{\xi, \Delta n_i^n} \quad \tfrac{1}{1+\Delta n_i^n} \left(K - \sigma \xi L^e + \Delta n_i^n \bar{P}_i \right) \tag{A.4}$$

$$s.t \qquad \Delta n_i^n \geq \tfrac{\gamma_s (1-\xi) - (k - \xi \sigma)}{\bar{P}_i} L^e \tag{A.5}$$

Kuhn-Tucker conditions of this problem imply that the shadow value of new capital is $\bar{\lambda} = \frac{\sigma \left(1+\Delta n_i^n\right)}{(\gamma_s - \sigma)\left(1+\Delta n_i^n\right)^2}$, while for indifference it has to be $\bar{P}_i = K - \sigma L^e$. Whenever $0 < \sigma \leq \gamma_s$, the shadow value of the bank is positive, $\bar{\lambda} > 0$, the inequality in A.5 would be binding, expected bank value is $\bar{V} = \frac{k-\sigma}{\gamma_s - \sigma} \gamma_s L^e$ and the bank is indifferent between increasing its capital ratio through a capital expansion or through deleverage. If $\bar{P}_i \gtrless K - \sigma L^e$ no equillibrium will exist.

If $\sigma < 0$, the shadow value of new capital is negative, $\bar{\lambda} < 0$, banks do not sell new stocks, $\Delta n_i^n = 0$, the value function characterized by A.3 is increasing in the amount of assets sold, so that $\xi = 1$, and $\bar{V} = K - \sigma L^e$.

If the bank decides not to refinance the loan portfolio, the value of the bank would be:

$$\bar{V} = \frac{1 - \xi}{\left(1 + \Delta n_i^n\right)} \left(\beta \left(r_{s'} + \lambda \right) \int_0^{\frac{r_{s'} + \frac{K - \sigma \xi L^e + \Delta n_i^n \bar{P}_i}{(1-\xi) L^e} - c}{r_{s'} + \lambda}} F_s \left(x \right) dx \right) L^e$$

The bank would prefer not to refinance whenever

$$\left(\beta\left(r_{s'}+\lambda\right)\int_0^{\frac{r_{s'}+\frac{K^e-\sigma\xi L^e+\Delta n_i^n\bar{P}_i}{(1-\xi)L^e}-c}{r_{s'}+\lambda}}F_s\left(x\right)dx\right)\geq\frac{K-\sigma\xi L^e+\Delta n_i^n\bar{P}_i}{\left(1-\xi\right)L^e}$$

or equivalently if

$$\left(\beta\left(r_{s'}+\lambda\right)\int_0^{\frac{r_{s'}+k'-c}{r_{s'}+\lambda}}F_s\left(x\right)dx\right)\geq k'$$

which can only be true for those banks becoming arbitrageurs.

Making use of the proof of Propositions 2 and 4, whenever loan market prices are above its book value, $P>1$, those banks holding a capital ratio $k\geq\delta\left(\frac{\sigma}{\sigma-\bar{\sigma}}\gamma_s\right)$ will prefer to buy loans in the secondary market as $V^1\geq V^0$ as long as $E_s\left(\bar{r_s}\right)=0$ which implies $\bar{P_i}=K-\sigma L^e$, while for those with $\gamma_s\leq k\leq\delta\left(\frac{\sigma}{\sigma-\bar{\sigma}}\gamma_s\right)$ it is optimal to sell the entire portfolio of loans in the secondary loan market. If the expected returns of equity were $E_s\left(\bar{r_s}\right)\gtreqless 0$ so that $\bar{P_i}\gtreqless K-\sigma L^e$ no equilibrium will exist.

On the other hand, when loan market prices are below its book value, $P\leq 1$, proof of Proposition 4 implies that banks holding a capital to loan ratio $\gamma_s<k\leq\bar{k^i}$ with $i=\{2,3\}$, and expressions provided in the text, will prefer to refinance the portfolio of loans and/or concede new loans to the economy while for those with $k>\bar{k^i}$ become arbitrageurs and its expected bank value is given by (18). So that whenever $\sigma-\bar{\sigma}+\delta\gamma_s-E_s\left(\bar{r_s}\right)>0$, buyers only invest in the loan market, $\Omega=\frac{k-\gamma_s}{k}$, and (18) becomes:

$$V^{'1}=\frac{k}{\gamma_s}\beta\left(\sigma-\bar{\sigma}+\delta\gamma_s+\frac{k-\sigma}{k}\gamma_s\right)L^e\Longleftrightarrow V^{'1}=kL^e+\beta\left(k\frac{\sigma-\bar{\sigma}}{\sigma\gamma_s}\sigma-\sigma\right)L^e$$

while if $\sigma-\bar{\sigma}+\delta\gamma_s-E_s\left(\bar{r_s}\right)<0$, buyers only invest in the equity market, $\Omega=0$, and

$$V'^1 = \beta\left(\sigma - \bar{\sigma} + \delta\gamma_s + k - \sigma + E_s\left(\bar{r_s}\right) > 0\left(\frac{k}{\gamma_s} - 1\right)\right)L^e \iff$$

$$\iff V'^1 = kL^e + \beta\left(\left(\frac{E_s\left(\bar{r_s}\right)}{\gamma_s} - \delta\frac{\gamma_s}{\gamma_s}\right)(k-\gamma_s) - \bar{\sigma}\right)$$

Making use of the definitions of $k^{\bar{i}}_{s',s}$ and Proposition 3, expressions shown in text follows. $\square$

Proof of Proposition 5. Consider, first, that assumption 1 is relaxed. Bank equity still being transferred at book value between shareholder generations, while those are capital constrained. And let me prove the first part of the proposition.

Definition of $\bar{P}$, then implies that $r_{s'} \geq \frac{1}{1-p_s}\left(\delta\gamma_s + c + p_s\lambda\right) \iff \bar{P} \geq 1$. When $P > 1$ those banks holding a capital ratio $\sigma < k \leq \bar{k^1}$ will decide to sell the portfolio of loans, so that the aggregate supply of loans to the economy would be $\int_{x^{\bar{k}}}^{x^{\sigma}} L^e dF_{s'}(x)$. Similarly, those banks holding a capital ratio $k > \bar{k^1}$, decide to increase leverage until the regulatory restriction is binding, and aggregate demand of assets in the economy would be $\int_0^{x^{\bar{k}}} \frac{(k-\gamma_s)}{\gamma_s} L^e dF_{s'}(x)$. An equilibrium price would be, implicitly, set by the equality of both expressions:

$$\int_0^{x^{\bar{k}}} \frac{(k-\gamma_s)}{\gamma_s} L^e dF_{s'}(x) = \int_{x^{\bar{k}}}^{x^{\sigma}} L^e dF_{s'}(x) \tag{A.6}$$

Proving the full statement, then, is equivalent to prove that, $\bar{P} \geq 1 \implies P > 1$ so that there exists an unique market price (above the book value) satisfying the zero excess demand condition A.6.

If $P > 1$ demand is increasing in price and non-negative whenever $k_{s'} \geq \bar{k^1} - (r_{s'} - c)$, reaching its lower bound when $P \geq \bar{P} + \bar{\sigma}\frac{\delta\gamma_s}{r_{s'} + k_{s'} - c + \sigma\gamma_s}$ while supply is increasing in price and strictly positive. Therefore, if for a sufficiently big price, supply is above demand the existence and unicity of the equilibrium price will be guaranteed. Consider the price $P = 1 + \sigma^a$, with $r_{s'} \geq r_s^f$ so that $\sigma^a > 0$, and let me prove that demand is above supply at this point.

Let me assume that the default rate that makes banks holding a capital ratio above the regulatory capital of the final state,γ_s, is above the average default rate of current state for any final state, $x^{\gamma_s} = \frac{r_{s'}+k_{s'}-c-\gamma_s}{r_{s'}+\lambda-\gamma_{s'}} > p_{s'}$. Then, the aggregate supply in the transition from s' to s, $S = \int_{x^{\bar{k}}}^{x^{\sigma}} L^e dF_{s'}(x)$, with $P = 1+\sigma^a \geq 1$ will be strictly bounded above, $S \leq (1-x^{\gamma_s}) F_{s'}(x^{\gamma_s})$, as in this case $F_{s'}(x^{\gamma_s}) > \frac{1}{2} > \frac{1}{2} F_{s'}(x^{\sigma_s})$ where $x^{\sigma_s} = \frac{r_{s'}+k_{s'}-c-\sigma}{r_{s'}+\lambda-\sigma}$.

Moreover, as $x^{\gamma_{s'}} > p_{s'}$, the unconditional expected value of capital satisfies $E_{s'}(K) > \gamma_s E_{s'}(L^e)$ so that, in aggregate terms, there is enough capital to hold all existing loans in the economy and cope with regulation under the final state. This allows me to write the following inequality:

$$LHS = D - S \geq E_{s'}\left(L^e 1_{\{-\sigma^a L^e > K\}}\right) - \frac{1}{\gamma_s} E_{s'}\left(K 1_{\{\gamma_s L^e > K\}}\right) = RHS$$

To prove that $RHS > 0$, so that demand is enough to satisfy supply, I should develop the expectations:

$$E_{s'}\left(L^e 1_{\{-\sigma^a L^e > K\}}\right) - \frac{1}{\gamma_s} E\left(K 1_{\{\gamma_s L^e > K\}}\right) = \int_{x^{\sigma_s}}^{1} \left(L^e - \frac{K}{\gamma_s}\right) dF_{s'}(x) - \frac{1}{\gamma_s} \int_{x^{\gamma_s}}^{x^{\sigma_s}} K dF_{s'}(x) =$$

$$= \frac{\lambda - (k_{s'} - c)}{\gamma_s} - \frac{r_{s'} + \lambda - \gamma_s}{\gamma_s} \int_{x^{\gamma_s}}^{1} F_{s'}(x)\, dx - S$$

As $\frac{\lambda-(k_{s'}-c)}{\gamma_s} - \frac{r_{s'}+\lambda-\gamma_s}{\gamma_s} \int_{x^{\gamma_s}}^{1} F_{s'}(x)\, dx > (1-x^{\sigma_s}) \left(1 + \frac{\sigma^a}{\gamma_s}\right) F_{s'}(x^{\sigma_s}) > (1-x^{\gamma_s}) F_{s'}(x^{\gamma_s})$, the difference between supply and demand is such that:

$$D - S > (1-x^{\gamma_s}) F_{s'}(x^{\gamma_s}) - S > 0$$

Thus, the equilibrium will exist and is unique if $x^{\gamma_s} > p_{s'}$. Let me now prove that $x^{\gamma_s} > p_{s'}$ whenever $r_{s'} \geq r_s^f$ and $k_{s'} \geq \gamma_{s'}$, or equivalently that:

$$\frac{k_{s'}}{1-p_{s'}} - \frac{\gamma_s}{1-p_s} > \gamma_s \left(1 - \frac{1}{\beta(1-p_s)}\right) + \frac{p_{s'}-p_s}{1-p_{s'}} \frac{\lambda+c}{1-p_s}$$

First, if both probabilities p_s and $p_{s'}$ are equal I have $\gamma_s = \gamma_{s'}$, above expression collapses to $\frac{k_{s'}-\gamma_{s'}}{1-p_s} \geq 0 > \gamma_s \left(1 - \frac{1}{\beta(1-p_s)}\right)$, which holds true and implies $x^{\gamma_s} > p_{s'}$. To analyze the effect of changes in $p_{s'}$, let me divide both terms by $\frac{p_{s'}-p_s}{1-p_{s'}} \frac{\lambda+c}{1-p_s}$ so that whenever $p_{s'} > p_s$ above inequality becomes:

$$\frac{(1-p_s)\,k_{s'}}{(p_{s'}-p_s)\,(\lambda+c)}-\frac{(1-p_{s'})\,\gamma_s}{(p_{s'}-p_s)\,(\lambda+c)}>\frac{\gamma_s\left(1-\frac{1}{\beta(1-p_s)}\right)}{\frac{p_{s'}-p_s}{1-p_{s'}}\frac{\lambda+c}{1-p_s}}+1$$

While if $p_{s'} < p_s$ I have:

$$\frac{(1-p_s)\,k_{s'}}{(p_{s'}-p_s)\,(\lambda+c)}-\frac{(1-p_{s'})\,\gamma_s}{(p_{s'}-p_s)\,(\lambda+c)}<\frac{\gamma_s\left(1-\frac{1}{\beta(1-p_s)}\right)}{\frac{p_{s'}-p_s}{1-p_{s'}}\frac{\lambda+c}{1-p_s}}+1$$

Computing the limit in the first inequality when $p_{s'} \to 1$ then renders:

$$\lim_{p_{s'}\to 1}\frac{(1-p_s)\,k_{s'}}{(p_{s'}-p_s)\,(\lambda+c)}-\frac{(1-p_{s'})\,\gamma_s}{(p_{s'}-p_s)\,(\lambda+c)}>\lim_{p_{s'}\to 1}\frac{\gamma_s\left(1-\frac{1}{\beta(1-p_s)}\right)}{\frac{p_{s'}-p_s}{1-p_{s'}}\frac{\lambda+c}{1-p_s}}+1\iff\frac{k_{s'}}{(\lambda+c)}-1>0$$

Which is also true given that the expected value of the bank under state s' when $p_{s'} = 1$ is $k_{s'} - (\lambda + c)$ and banking activities would only be profitable if $k_{s'} > (\lambda + c)$. Similarly, computing the limit when $p_{s'} \to 0$ in the second inequality leads to:

$$(\delta-(1-p_s))\,\gamma_s\geq-\left(k_{s'}\,(1-p_s)+p_s\,(c+\lambda)\right)\iff p_s\,(k_{s'}-\gamma_s-c-\lambda)\leq\delta\gamma_s+k_{s'}-\gamma_s$$

Hence, for the inequality to be true I should require $|p_s| \leq |\frac{k_{s'}-\gamma_s+\delta\gamma_s}{k_{s'}-\gamma_s-(c+\lambda)}|$, which holds true given that $|\frac{k_{s'}-\gamma_s+\delta\gamma_s}{k_{s'}-\gamma_s-(c+\lambda)}| > 1$. Therefore $x^{\gamma_s} > p_{s'}$ whenever $r_{s'} \geq r_s^f$ for any feasible combination of probabilities$\{p_{s'}, p_s\}$ so that there exists a price $\bar{P} > P \geq 1+\sigma^a$ such that $D - S = 0$.

Let me now turn to the second part of the proposition. Consider $P < 1$, so that according to Corollary 1 the decision of bank managers of overcapitalized banks would depend not only on loan prices but also in equity ones, while asset sellers would be indifferent between selling loans and equity, at a price $\bar{P}_i = K - \sigma L^e$, in an amount such that final capital is equal to regulatory one. This way, the amount of assets bought by each bank holding a capital to loan ratio $k > \bar{k}^i$ with $i = \{2, 3\}$ is, by equation (9), $D^i = \Delta n_i^n P_x + \frac{\Omega}{1-\Omega}\gamma_s L^e = \frac{K-\gamma_s L^e}{\gamma_s}$ while the amount of assets sold by each individual bank with a capital to loan ratio $\sigma < k < \gamma_s$ would be such that $\Delta n_i^b \bar{P}_i = \gamma_s L^e - K - \xi \left(\gamma_s - \sigma \right) L^e$ to comply with capital regulation, while the supply of assets would be $\xi L^e + \Delta n^b \bar{P}_i$. Consequently, substituting ξ in the individual supply equation implies that $S^i = \frac{\gamma_s - k}{\gamma_s - \sigma} L^e - \Delta n_i^b \frac{k - \sigma}{\gamma_s - \sigma} L^e + \Delta n_i^b \left(k - \sigma \right) L^e$. Integration of individual demand and supply equations, over the relevant interval, then yields the expression shown in text.

As in the proof of the first part of this proposition, I have now checked the validity of the equation stated in the text for those cases where $P < 1$, the only thing left is to prove that there exists a unique solution to the equality of aggregate supply and demand schedules such that when $\bar{P} < 1 \Longrightarrow P < 1$. In order to do so, let me start by considering the case when $\Delta n_i^b = 0$, as if it is not the case asset supply will always be lower and its derivative with respect to price greater so that the proof will still hold.

Consider $\sigma^a < 0$, so that $r_{s'} < r_s^f$ and assume $P \geq \bar{P}$. The expression of the capital threshold, $\bar{k^2}$, set in text, then implies that $\bar{k^2} \left(\bar{P} \right) \to \infty$, so that aggregate asset demand is zero, $D = 0$. Given that $\frac{d\bar{k}}{dP} = \frac{\gamma_{s'} \bar{\sigma}}{\left(\sigma - \bar{\sigma} \right)^2} > 0$, for any price $P \geq \bar{P}$, I would have $D = 0$.

On the other hand, if $P \geq 1 - \gamma_s$, aggregate supply is non negative, $S \geq 0$. Continuity of supply and demand functions, then, imply that there exists at least one price at which $S = D$. In order to prove the unicity of such equilibrium, I proceed by contradiction. Let me assume that there are two equilibrium prices P, P^1 with $1 > P > P^1$, such that $D \left(k_{s'}, r_{s'}, P \right) = D = S = S \left(k_{s'}, r_{s'}, P \right)$ and $D \left(k_{s'}, r_{s'}, P^1 \right) = D' = S' = S \left(k_{s'}, r_{s'}, P^1 \right)$. Given the functional form of aggregate demand, I have that

$$D' = D + \frac{\bar{k^2}' - \gamma_s}{\gamma_s} \left(1 - x^{\bar{k}'} \right) F_{s'} \left(x^{\bar{k}'} \right) - \frac{\bar{k^2} - \gamma_s}{\gamma_s} \left(1 - x^{\bar{k}} \right) F_{s'} \left(x^{\bar{k}} \right) + \frac{r_{s'} + \lambda - \gamma_s}{\gamma_s} \int_{x^{\bar{k}}}^{x^{\bar{k}'}} F_{s'} \left(x \right) dx \tag{A.7}$$

while supply satisfies

$$S' = \left(1 + \frac{(\sigma' - \sigma)}{\gamma_{s'} - \sigma}\right)\left(S + \left(1 - x^{\sigma'}\right) F_s\left(x^{\sigma'}\right) - \left(1 - x^{\sigma}\right) F_s\left(x^{\sigma}\right) + \frac{r_{s'} + \lambda - \gamma_s}{\gamma_s - \sigma}\int_{x^{\sigma'}}^{x^{\sigma}} F_{s'}(x)dx\right) - \frac{(\sigma' - \sigma)}{\gamma_{s'} - \sigma}\left(1 - x^{\sigma'}\right) F_{s'}\left(x^{\sigma'}\right) \quad \text{(A.8)}$$

As $D = S$ and $D' = S'$, I could substitute equation A.8 into A.7 so, after some algebra, I get $D = \left(1 - x^{\sigma'}\right) F_{s'}\left(x^{\sigma'}\right) - (D' - D)$ or equivalently $D' = \left(1 - x^{\sigma'}\right) F_{s'}\left(x^{\sigma'}\right)$ which given the expression of aggregate supply implies $D' > S'$. Therefore when $\sigma^a < 0$, the equilibrium is unique and such that $1 - \gamma_s \leq P < 1$.

When assumption 1 is fully considered, all the entities with $k > \gamma_s$ have unlimited access to new capital. A distortion on demand, as presented above, would take place if any bank finds optimal to increase capital to a level $k^n > \bar{k}^i$. Recalling that 2.8 implies:

$$\bar{V} - K = \beta K \frac{\sigma - \bar{\sigma}}{\gamma_s} - \beta \sigma L^e$$

And taking derivatives with respect to capital, I have:

$$\frac{d\bar{V}}{dK} - 1 = \beta \frac{\sigma - \bar{\sigma}}{\gamma_s} + \beta\left(\frac{K}{\gamma_s} - L^e\right)\frac{d\sigma}{dK} \quad \text{(A.9)}$$

A capital expansion taking place whenever $\frac{d\bar{V}}{dK} > 0$, or equivalently when

$$\frac{d\sigma}{dK} > -\frac{\sigma - \bar{\sigma}}{K - \gamma_s L^e} \quad \text{(A.10)}$$

Given the continuity of the CDF, the probability of any bank ending up with a capital K is zero, so that:

$$\frac{d\sigma}{dK} = 0$$

This, in turn, implies that A.10 holds for any capital K, the only equilibrium price implying $\sigma = \bar{\sigma}$, and no arbitrage profits $\bar{V} = K$. However, comparing this new situation with the original one, banks holding $K \leq \bar{k}^i L^e$ are indifferent between its original capital and the after-capital-injection level, K^n. On the other hand, those for which $K > \bar{k}^i L^e$ would be strictly worse. Consequently, neither banks nor arbitrageurs are interested on increasing capital to finance the acquisition of new assets and previome proof suffices. □

Proof of Corollary 2. i) Let me first simplify the notation so that I omit in what follows the state sub-index, s', s. Assume $\sigma^a \geq 0$, define $H(\sigma) = (r + \lambda - \sigma) \int_0^{x^\sigma} F(x)\,dx$ and $H(\bar{k}) = \left(r + \lambda - \bar{k}\right) \int_0^{x^{\bar{k}}} F(x)\,dx$ with $\bar{k} = \bar{k}^1$. Then the supply of loans for sale is $S = \frac{dH(\bar{k})}{d\bar{k}} - \frac{dH(\sigma)}{d\sigma}$, demand is $D = \frac{\gamma - \bar{k}}{\gamma}\frac{dH(\bar{k})}{dk} + \frac{H(\bar{k})}{\gamma}$ and that the value of the bank is $V = H(\sigma) - (1-\beta)\frac{\sigma}{\bar{k}} H(\bar{k})$.

The derivative of bank value with respect to k is $\frac{dV}{dk} = \frac{\partial V}{\partial \sigma}\frac{\partial \sigma}{\partial k} + \frac{\partial V}{\partial k}$. In order to identify the value of $\frac{\partial \sigma}{\partial k}$, let me recall that in equilibrium $S - D = 0$ so, by the envelope theorem, it has to be true that $\frac{d(S-D)}{dk} = \frac{\partial(S-D)}{\partial \sigma}\frac{\partial \sigma}{\partial k} + \frac{\partial(S-D)}{\partial k} = 0$, which implies $\frac{\partial \sigma}{\partial k} = -\frac{\frac{\partial(S-D)}{\partial k}}{\frac{\partial(S-D)}{\partial \sigma}}$ so that $\frac{dV}{dk} = -\frac{\partial V}{\partial \sigma}\frac{\frac{\partial(S-D)}{\partial k}}{\frac{\partial(S-D)}{\partial \sigma}} + \frac{\partial V}{\partial k}$.

Assume that $\frac{dV}{dk} < 0$, and let me prove that this is true. If $\frac{dV}{dk} < 0$, then

$$-\frac{\frac{\partial(S-D)}{\partial k}}{\frac{\partial(S-D)}{\partial \sigma}} < -\frac{\frac{\partial V}{\partial k}}{\frac{\partial V}{\partial \sigma}} \tag{A.11}$$

.

As $\frac{\partial V}{\partial k} = F(x^\sigma) - (1-\beta)\frac{1-P}{\bar{k}} F\left(x^{\bar{k}}\right)$ and $\frac{\partial V}{\partial \sigma} = -(1-\beta) S$, A.11 could be rewritten as:

$$\left(\bar{k}\frac{\partial^2 H\left(\bar{k}\right)}{\partial k^2}\right)\left(\frac{1}{1-x^{\bar{k}}} + \frac{\bar{k}\bar{\sigma}}{\sigma\left(\sigma - \bar{\sigma}\right)}\frac{\frac{\partial V}{\partial k}}{\frac{\partial V}{\partial \sigma}}\right) \geq \left(\gamma\frac{\partial^2 H\left(\sigma\right)}{\partial \sigma^2}\right)\left(\frac{1}{1-x^\sigma} + \frac{\frac{\partial V}{\partial k}}{\frac{\partial V}{\partial \sigma}}\right) - F\left(x^{\bar{k}}\right) \tag{A.12}$$

The left hand side (LHS) of the equation is strictly positive while the right hand side is negative as$\left(\frac{1}{1-x^{\sigma}}+\frac{\frac{\partial V}{\partial k}}{\frac{\partial V}{\partial \sigma}}\right)<0$. Consequently, the RHS is strictly smaller than the LHS and my assumption true. This implies that, if under each state, s, $\sigma^{a}>0$, capital would be in the corner, $k^{*}=\gamma_{s}$.

Moreover, assume that the interest rate is such that $\sigma^{a}\geq 0$, for any state, so that $r_{s}\geq r_{h}^{f}$ and $P\geq 1$, and take $k_{s}^{*}=\gamma_{s}$. The expected value for a bank of continuing with their banking activities would be $V_{s}=\beta\left[q_{s,h}E_{s}\left(V_{s,h}\right)+\left(1-q_{s,h}\right)E_{s}\left(V_{s,l}\right)\right]>\beta E_{s}\left(V_{s,h}\right)$. Given the expression of the value function provided in Corollary 1, $\bar{V}$, the expected bank value satisfies

$$\beta E_{s}\left(V_{s,h}\right)\geq\beta\int_{0}^{\frac{r_{s}+\gamma_{s}-c}{r_{s}+\lambda}}KdF_{s}\left(x\right)\geq\gamma_{s}$$

As a consequence, the difference between the expected value of capital when the bank decides to continue with their activities, and the cost of such capital will be strictly above zero, $V_{s}>\gamma_{s}-\gamma_{s}=0$, which violates the zero profit condition and cannot be an equilibrium.

On the other hand, let me assume now that $\sigma^{a}<0$ for any state, so that $r_{s}<r_{l}^{f}$, and without loss of generality consider, $\Delta n_{i}^{b}=0$ so that loan market supply is $S=\frac{r+\lambda-\gamma_{s'}}{\gamma_{s'}}\int_{x^{\gamma}}^{x^{\sigma}}F(x)dx-(1-x^{\sigma})F\left(x^{\sigma}\right)$, and the expected value for a bank of continuing with their activities would be $V_{s}=\beta\left[q_{s,h}E_{s}\left(V_{s,h}\right)+\left(1-q_{s,h}\right)E_{s}\left(V_{s,l}\right)\right]$. Given that the average default probability is higher in state h than in state l, it is trivial that $V_{s}<\beta E_{s}\left(V_{s,l}\right)$. Thus, under the characterization of $V_{s,s'}$ provided in Corollary 1, I have:

$$V_{s}<\beta\gamma_{l}\left[\int_{0}^{x^{\sigma}}\left(1-x\right)dF_{s}(x)-\frac{1}{\gamma_{l}}\left(1-\beta\left(\sigma_{s,l}-\bar{\sigma_{s,l}}\right)\right)S-\beta\frac{\bar{\sigma_{s,l}}}{\gamma_{l}}\int_{0}^{x^{\bar{k}}}\left(1-x\right)dF_{s}(x)\right]\tag{A.13}$$

Hence, $V_{s}<\beta\gamma_{l}\int_{0}^{x^{\sigma}}\left(1-x\right)dF_{s}(x)<\beta\gamma_{l}$ and for any $k\geq\gamma_{s}$, the expected profits of banking activities are negative, $V_{s}-k<0$, which cannot constitute an equilibrium.

Using these results and the first order stochastic dominance of the recessive default distribution over the expansionary one, I have shown that a simultaneome equilibrium could only occur if $r_{s}^{*}\in\left[r_{l}^{f},r_{h}^{f}\right]$.

In state l, and given Proposition 5, there is always trading of loans in the secondary loan market as $r_l^* \geq r_l^f$

ii) and iii) Consider the specification of bank value function set in Corollary 1, then:

a) If $r_{s'} < r_s^f$ and $\sigma_l - \sigma > E_s\left(\bar{r_{s'}}\right)$

$$V_{s'}^1 - k_{s'} = \begin{cases} -k_{s'} & \gamma_s > k_{s'} + (r_{s'} - c) \\ \beta \int_0^{x^{\gamma_{s'}}} kL^e dF_{s'}(x) - k_s & \frac{\gamma_s^2}{\gamma_s - \bar{\sigma}} > k_{s'} + (r_{s'} - c) > \gamma_s \\ \beta\left(A + B + C\right) - k_{s'} & \lambda + r_{s'} > k_{s'} + (r_{s'} - c) > \frac{\gamma_s^2}{\gamma_s - \bar{\sigma}} \\ \beta\left(r_{s'} + k_{s'} - c - p_{s'}\left(r_{s'} + \lambda\right)\right) - k_{s'} & k_{s'} > \lambda + c \end{cases}$$

where $A = \frac{r_{s'} + \lambda - \sigma}{\gamma_s - \sigma} \int_{x^\gamma}^{x^\sigma} F_{s'}\left(x\right) dx$, $B = \left(r_{s'} + \lambda\right) \int_0^{x^\gamma} F_{s'}\left(x\right) dx$ and $C = \beta\sigma \frac{r_{s'} + \lambda - \bar{k^2}}{\bar{k^2}} \int_0^{x^{\bar{k^2}}} F_{s'}\left(x\right) dx$

b) If $r_{s'} < r_s^f$ and $\sigma_l - \sigma < E_s\left(\bar{r_{s'}}\right)$

$$V_{s'}^2 - k_{s'} = \begin{cases} -k_{s'} & \gamma_s > k_{s'} + (r_{s'} - c) \\ \beta \int_0^{x^{\gamma}} kL^e dF_{s'}(x) - k_{s'} & \nu > k_{s'} + (r_{s'} - c) > \gamma_s \\ \beta\left(A + B + C\right) - k_{s'} & \lambda + r_{s'} > k_{s'} + (r_{s'} - c) > \nu \\ \beta\left(r_{s'} + k_{s'} - c - p_{s'}\left(r_{s'} + \lambda\right)\right) - k_{s'} & k_{s'} > \lambda + c \end{cases}$$

where $\nu = \gamma_s + \gamma_s \frac{\bar{\sigma}}{E_s(\bar{r_{s'}}|\sigma = \gamma_s) - \delta\gamma_s} < \gamma_s + \gamma_s \frac{\bar{\sigma}}{\gamma_s - \bar{\sigma}}$.

If $E_s\left(\bar{r_{s'}}\right) = \frac{\sigma}{\gamma_s - \sigma} - c^e$, I have $\nu = \left(1 - \gamma_s\right)\bar{\sigma} + \gamma_s$ and where $A = \frac{r_{s'} + \lambda - \sigma}{\gamma_s - \sigma} \int_{x^\gamma}^{x^\sigma} F_{s'}\left(x\right) dx$, $B = \left(r_{s'} + \lambda\right) \int_0^{x^\gamma} F_{s'}\left(x\right) dx$ and $C = \beta\sigma \frac{r_{s'} + \lambda - \bar{k^3}}{\bar{k^3} - \gamma_s} \int_0^{x^{\bar{k^3}}} F_s\left(x\right) dx$

c) If $r_{s'} \geq r_s^f$

$$V_{s'}^3 - k_{s'} = \begin{cases} -k_{s'} & \gamma_s > k_{s'} + (r_{s'} - c) \\ \beta\left(A + B\right) - k_{s'} & \lambda + r_{s'} > k_{s'} + (r_{s'} - c) > \gamma_s \\ \beta\left(r_{s'} + k_{s'} - c - p_{s'}\left(r_{s'} + \lambda\right)\right) - k_{s'} & \lambda + c > k_{s'} \end{cases}$$

where $A = \left(r_{s'} + \lambda - \sigma\right) \int_0^{x^\sigma} F_{s'}\left(x\right) dx$ and $B = -\left(1 - \beta\right)\sigma \frac{r_{s'} + \lambda - \bar{k^1}}{\bar{k^1}} \int_0^{x^{\bar{k^1}}} F_{s'}\left(x\right) dx$

Given the characterization of the equilibrium interest rate range, set in previous part of the proof, the value function, $V_{s'} - k_{s'}$, is continuous on $r_{s'}$ by the theorem of the maximum, lies strictly below zero at the lower bound of that range and strictly above zero at the upper bound. Then $\frac{dV_{s'}}{dr_{s'}} = \frac{\partial V_{s'}}{\partial r_{s'}} + \frac{\partial V_{s'}}{\partial k_{s'}} \frac{\partial k_{s'}}{\partial r_{s'}}$, when the equilibrium is interior $\frac{\partial V_{s'}}{\partial k_{s'}} = 0$, by the envelope theorem, while if $k_{s'} = \gamma_{s'}$ I have $\frac{\partial k_{s'}}{\partial r_{s'}} = 0$. Therefore the second term is always zero so that the total derivative with respect to

r_s is equal to its partial derivative. Given the characterization of the value function made in a), b) and c) it should be clear that the value function is strictly increasing in r_s, independently of the capital ratio, $k_{s'}$, given that both, arbitrageurs entity value and deleveraging banks value are increasing in that spread. Consequently $\frac{dV_{s'}}{dr_{s'}} > 0$ and the interest rate spread is unique.

Moreover, computing first order derivatives with respect to capital in above specification of the value function I get that:

a) If $r_{s'} < r_s^f$ and $\sigma_l - \sigma > E_s\left(\bar{r_{s'}}\right)$

$$\frac{dV_{s'}^1}{dk_{s'}} - 1 = \begin{cases} -1 & \gamma_s > k_{s'} + (r_{s'} - c) \\ \beta\gamma_{s'}\left(1 - x^{\gamma_{s'}}\right)\frac{dF_{s'}(x)}{dx}|_{x=x^{\gamma_{s'}}} + 2\beta - 1 > 0 & \frac{\gamma_s^2}{\gamma_s - \bar{\sigma}} > k_{s'} + (r_{s'} - c) > \gamma_s \\ \frac{\partial V_{s'}^1}{\partial k_{s'}} + \frac{\partial \sigma}{\partial k_{s'}}\frac{\partial V_{s'}^1}{\partial \sigma} - 1 \gtreqless 0 & \lambda + r_{s'} > k_{s'} + (r_{s'} - c) > \frac{\gamma_s^2}{\gamma_s - \bar{\sigma}} \\ \beta - 1 \leq 0 & k_{s'} > \lambda + c \end{cases}$$

b) If $r_{s'} < r_s^f$ and $\sigma_l - \sigma < E_s\left(\bar{r_{s'}}\right)$

$$\frac{dV_{s'}^2}{dk_{s'}} - 1 = \begin{cases} -1 & \gamma_s > k_{s'} + (r_{s'} - c) \\ \beta\left(\gamma_s\left(1 - x^{\gamma_s}\right)\frac{dF_{s'}(x)}{dx}|_{x=x^{\gamma_s}} + 2\right) - 1 > 0 & \nu > k_{s'} + (r_{s'} - c) > \gamma_s \\ \frac{\partial V_{s'}^2}{\partial k_{s'}} + \frac{\partial \sigma}{\partial k_{s'}}\frac{\partial V_{s'}^2}{\partial \sigma} - 1 \gtreqless 0 & \lambda + r_{s'} > k_{s'} + (r_{s'} - c) > \nu \\ \beta - 1 \leq 0 & k_{s'} > \lambda + c \end{cases}$$

c) If $r_{s'} \geq r_s^f$

$$\frac{dV_{s'}^3}{dk_{s'}} - 1 = \begin{cases} -1 & \gamma_s > k_{s'} + (r_{s'} - c) \\ \frac{\partial V_{s'}^3}{\partial k_{s'}} + \frac{\partial \sigma}{\partial k_{s'}}\frac{\partial V_{s'}^3}{\partial \sigma} - 1 < 0 & \lambda + r_{s'} > k_{s'} + (r_{s'} - c) > \gamma_s \\ \beta - 1 \leq 0 & \lambda + c > k_{s'} \end{cases}$$

Note that the first order derivative in the case $r_{s'} \geq \frac{1}{1-p_s}\left(\delta\gamma_s + c + p_s\lambda\right)$ is negative and has already been computed in the proof of statement i). The exact expressions of the first order derivatives for the cases $r_{s'} < r_s^f$ with $\nu - (r_{s'} - c) > k_{s'} > \gamma_s - (r_{s'} - c)$ and $\nu = (1 - \gamma_s)\bar{\sigma} + \gamma_s$ or $\nu = \gamma_s\frac{\gamma_s}{\gamma_s - \bar{\sigma}}$ are complex, and their expressions are skipped for simplicity.

a) If $r_{s'} < r_s^f$ and $\sigma_l - \sigma > E_s\left(\bar{r_{s'}}\right)$

$$\frac{d^2V^1_{s'}}{dk^2_{s'}} = \begin{cases} 0 & \gamma_s > k_{s'} + (r_{s'} - c) \\ \beta\frac{\gamma_s}{r_{s'}+\lambda-\gamma_s}\left((1-x^{\gamma_s})\frac{d^2F_{s'}(x)}{dx^2}|_{x=x^{\gamma_s}} - \frac{dF_{s'}(x)}{dx}|_{x=x^{\gamma_s}}\right) & \frac{\gamma_s^2}{\gamma_s-\bar{\sigma}} > k_{s'} + (r_{s'} - c) > \gamma_s \\ A \gtreqless 0 & \lambda + r_{s'} > k_{s'} + (r_{s'} - c) > \frac{\gamma_s^2}{\gamma_s-\bar{\sigma}} \\ 0 & k_{s'} > \lambda + c \end{cases}$$

where $A = \frac{\partial^2 V^1_{s'}}{\partial k^2_{s'}} + 2\frac{\partial^2 V^1_{s'}}{\partial k_{s'}\partial\sigma}\frac{\partial\sigma}{\partial k_{s'}} + \frac{\partial^2 V^1_{s'}}{\partial\sigma^2}\left(\frac{\partial\sigma}{\partial k_{s'}}\right)^2 + \frac{\partial V^1_{s'}}{\partial\sigma}\left(\frac{\partial^2\sigma}{\partial k^2_{s'}}\right)$

b) If $r_{s'} < r^f_s$ and $\sigma_l - \sigma < E_s\left(\bar{r_{s'}}\right)$

$$\frac{d^2V^2_{s'}}{dk^2_{s}} = \begin{cases} 0 & \gamma_s > k_{s'} + (r_{s'} - c) \\ \beta\frac{\gamma_s}{r_{s'}+\lambda-\gamma_s}\left((1-x^{\gamma_s})\frac{d^2F_{s'}(x)}{dx^2}|_{x=x^{\gamma_s}} - \frac{dF_{s'}(x)}{dx}|_{x=x^{\gamma_s}}\right) & \nu > k_{s'} + (r_{s'} - c) > \gamma_s \\ A \gtreqless 0 & \lambda + r_{s'} > k_{s'} + (r_{s'} - c) > \nu \\ \beta - 1 \leq 0 & k_{s'} > \lambda + c \end{cases}$$

where $A = \frac{\partial^2 V^2_{s'}}{\partial k^2_{s'}} + 2\frac{\partial^2 V^2_{s'}}{\partial k_{s'}\partial\sigma}\frac{\partial\sigma}{\partial k_{s'}} + \frac{\partial^2 V^2_{s'}}{\partial\sigma^2}\left(\frac{\partial\sigma}{\partial k_{s'}}\right)^2 + \frac{\partial V^2_{s'}}{\partial\sigma}\left(\frac{\partial^2\sigma}{\partial k^2_{s'}}\right)$

c) If $r_{s'} \geq r^f_s$

$$\frac{d^2V^3_{s'}}{dk^2_{s'}} = \begin{cases} 0 & \gamma_s > k_{s'} + (r_{s'} - c) \\ A < 0 & \lambda + r_{s'} > k_{s'} + (r_{s'} - c) > \gamma_s \\ 0 \leq 0 & \lambda + c > k_{s'} \end{cases}$$

where $A = \frac{\partial^2 V^2_{s'}}{\partial k^2_{s'}} + 2\frac{\partial^2 V^2_{s'}}{\partial k_{s'}\partial\sigma}\frac{\partial\sigma}{\partial k_{s'}} + \frac{\partial^2 V^2_{s'}}{\partial\sigma^2}\left(\frac{\partial\sigma}{\partial k_{s'}}\right)^2 + \frac{\partial V^2_{s'}}{\partial\sigma}\left(\frac{\partial^2\sigma}{\partial k^2_{s'}}\right)$

Therefore for the equilibrium to be interior it has to be the case that $k_{s'} > \gamma_s - (r_{s'} - c)$ whenever $r_{s'} < r^f_s$. Given i) it follows that $k_{s'} > \gamma_h - (r_{s'} - c)$. Moreover, given that $\frac{\partial V^2_{s'}}{\partial k_{s'}} + \frac{\partial\sigma}{\partial k_{s'}}\frac{\partial V^2_{s'}}{\partial\sigma} - 1 > -1$ and $\frac{dV^i_{s'}}{dk_{s'}} - 1 > 0\ \forall i = \{1, 2\}$ whenever $\gamma_s - (r_{s'} - c) + \nu > k_{s'} > \gamma_s - (r_{s'} - c)$ it follows that the equilibrium interest rate, $r^*_{s'}$, when $k_{s'} < \gamma_h - (r_{s'} - c)$ is strictly greater than that when $k_{s'} > \gamma_h - (r_{s'} - c)$. This implies that the only stationary solution to the problem has to happen in this last situation. If some bank in the economy would choose a level of capital $k_{s'} < \gamma_h - (r_{s'} - c)$, given $r_{s'}$, any other bank could increase the level of capital to a point where $k_{s'} > \gamma_h - (r_{s'} - c)$ and make profits. Similarly, the first derivative is strictly decreasing for any $\beta < 1$ whenever $k_{s'} > \lambda + c$. Consequently, $\lambda + c > k_{s'} > \gamma_s - (r_{s'} - c)$ which is the expression shown in text.

iv) The proof that there is a positive probability of some entrepreneurs facing refinancing constraints comes directly from the fact that when $s = l$ there is a positive probability of some banks being bankrupted, $1 - F_l\left(x^{\sigma_{l,l}}\right) > 0$. Given that $P_{l,h} < P_{l,l}$ it follows that $1 - F_l\left(x^{\sigma_{l,h}}\right) > 1 - F_l\left(x^{\sigma_{l,l}}\right) > 0$. Similarly when $s = h$ I have $1 > x^{\sigma_{h,l}} > 0$ so that $1 - F_h\left(x^{\sigma_{h,l}}\right) > 0$. Also, as $x^{\sigma_{h,l}} > x^{\sigma_{h,h}}$ I have that $1 - F_h\left(x^{\sigma_{h,h}}\right) > 1 - F_h\left(x^{\sigma_{h,l}}\right) > 0$. As bankrupted banks cannot refinance their loans it follows that there is a positive probability of some entrepreneurs facing refinancing constraints in both $s = h$ and $s = l$. The fact that when the economy ends up in an expansion $x^{\sigma_{l,l}}, x^{\sigma_{h,l}}, x^{k^{\bar{1}}_{l,l}}, x^{k^{\bar{1}}_{h,l}} > 0$ while $x^{\sigma_{l,l}} > x^{k^{\bar{1}}_{l,l}}$ and $x^{\sigma_{h,l}} > x^{k^{\bar{1}}_{h,l}}$ imply that there is a positive probability $F_{s'}\left(x^{\sigma_{s',l}}\right) - F_{s'}\left(x^{k^{\bar{1}}_{s',l}}\right) > 0$ of some banks being interested into giving new loans to entrepreneurs when $s = l$. In the case $s = h$ and the equilibrium is interior, $k^*_h > \gamma_h$, I have $x^{k^*_h} > x^{k^{\bar{i}}_{s',h}} \geq 0 \ \forall i = \{2, 3\}$ so that there is a positive probability $F_{s'}\left(x^{k^*_h}\right) - F_{s'}\left(x^{k^{\bar{i}}_{s',h}}\right) > 0$ of a bank being interested into giving loans to entrepreneurs.

v) The proof of the efficiency of market prices comes directly from the range of suitable interest rate spreads set in i) along with the proof of Proposition 5. Given that $r^*_s \in \left[(\delta\gamma_l + c + p_l\lambda)\frac{1}{1-p_l}, (\delta\gamma_h + c + p_h\lambda)\frac{1}{1-p_h}\right]$ I have that $r^*_s > (\delta\gamma_l + c + p_l\lambda)\frac{1}{1-p_l}$ so that $\bar{P}_{s,l} > 1$ and thus $P_{s,l} > 1$. Similarly $r^*_s < (\delta\gamma_h + c + p_h\lambda)\frac{1}{1-p_h}$ which implies $\bar{P}_{s,h} < 1$ or equivalently $P_{s,h} < 1$

vi) If the solution to the problem is interior it is the case that $k_s > \gamma_s$. Given the characterization of the derivatives set in iii), shareholders of banks holding inefficient levels of capital, $k < k^*_s$, face increasing returns to capital. Consequently bank managers see it optimal to increase the level of capital via a capital injection from shareholders while those would be willing to provide such capital.

vii) The optimality of refinanciation practices when $s = h$ comes directly from the proof of Corollary 1. $\square$

Value of 1 share of the Equity Index acquired by arbitrageurs. Assume arbitrageurs assign a valuation to next period equity according to the intrinsic value of each of the banks issuing equity. Then, given that at current date the individual price of new equity is $\bar{P}_i = K - \sigma L^e$ the unit value weighted index price is $P_x = \frac{\int_{x\gamma_s}^{x^\sigma} \Delta n_i^b \bar{P}_i dF_{s'}(x)}{\int_{x\gamma_s}^{x^\sigma} \Delta n_i^b dF_{s'}(x)}$ while, in equilibrium, the expected value of that index is $E_s\left(P_x'\right) = \frac{\frac{\gamma_s}{\gamma_s-\sigma}\int_{x\gamma_s}^{x^\sigma} \Delta n_i^b \bar{P}_i dF_{s'}(x)}{\int_{x\gamma_s}^{x^\sigma} \Delta n_i^b dF_{s'}(x)}$. Consequently, $\frac{P_x' - (1+c^e)P_x}{P_x} = \frac{\gamma_s}{\gamma_s-\sigma} - 1 - c^e = \frac{\sigma}{\gamma_s-\sigma} - c^e$ which is the expression shown in text. □

The problem solved by Bank managers when $\alpha > 0$ is.

$$\begin{aligned} &\underset{k_s}{max} \quad V_s\left(k_s, B|r_s^*\right) - k_s \\ &s.t: \qquad\quad k_s \geq \gamma_s \end{aligned}$$

Where the expressions of V_s are identical to that shown in the proof of Corollary 2 substituting c and λ by the expressions of c' and λ' shown in Definition 1, and where equilibrium bond prices P^{u*}, are given by the zero profit condition $V_s\left(k_s, B|r_s^*\right) = k_s$. □

Regulatory capital under Basel Environment and Cumulative distribution formula. Under the standard IRB approach of Basel II regulatory capital of corporate exposures is measured according to the following formula:

lending restrictions restrictions

$$\gamma_s = \lambda\Phi\left(\frac{\Phi^{-1}\left(p_s\right) + \sqrt{\rho_s}\Phi^{-1}\left(0.999\right)}{\sqrt{1-\rho_s}}\right)$$

where the default correlation parameter, ρ_s, is computed according to the following formula $\rho_s = 0.12\left(2 - \frac{1-e^{-50p_s}}{1-e^{-50}}\right)$

However, the formula of regulatory capital under Basel II accommodates for the existence of both Tier I and Tier II types of capital while imposing the additional restriction that half of that capital requirement should be covered by Tier 1 capital. Given that my model just accommodates for the existence of Tier 1 capital instruments (essentially equity core capital) I decide to multiply above expression by a $\frac{1}{2}$ factor. The foundations of that formula comes from the Single factor Vasicek credit model (Vasicek (2002)) under which the state contingent CDF of the default rate

x is given by $F_s(x) = \Phi\left(\frac{\sqrt{1-\rho_s}\Phi^{-1}(x)-\Phi^{-1}(p_s)}{\sqrt{\rho_s}}\right)$ and where p_s is the state contingent average default rate. $\square$

C. Characterization of the Welfare Measure

The corresponding expressions for each of the state contingent components of the Welfare Measure are:

$$NC_{s',s} = (1-p_s)\begin{cases} \int_{x^{\bar{k}}}^{x^{\sigma}} \frac{k-\sigma}{k_s^*}(1-x)\,dF_{s'}(x) & P>1 \\ \int_{x^{\bar{k}_{s,s'}}}^{x^{k_{s,s'}}} \frac{k-k_s^*}{k_s^*}(1-x)\,dF_{s'}(x) & P<1 \end{cases}$$

$$R_{s',s} = (1-p_s)\begin{cases} \int_{x^{k_s}}^{x^{\gamma_s}} \frac{k-k_s^*}{k_s^*}(1-x)\,dF_{s'}(x) - \int_{x^{\gamma_s}}^{x^{\sigma}} \frac{\gamma_s-k_s^*}{k_s^*}\frac{k-\sigma}{\gamma_{s'}-\sigma}(1-x)\,dF_{s'}(x) & \sigma_l-\sigma > E_s\left(\bar{r_{s'}}\right) \\ \int_{x^{k_s}}^{x^{\gamma_s}} \frac{k-k_s^*}{k_s^*}(1-x)\,dF_{s'}(x) - \int_{x^{\gamma_s}}^{x^{\sigma}} \frac{\gamma_s-k_s^*}{k_s^*}(1-x)\,dF_{s'}(x) & \sigma_l-\sigma < E_s\left(\bar{r_{s'}}\right) \end{cases}$$

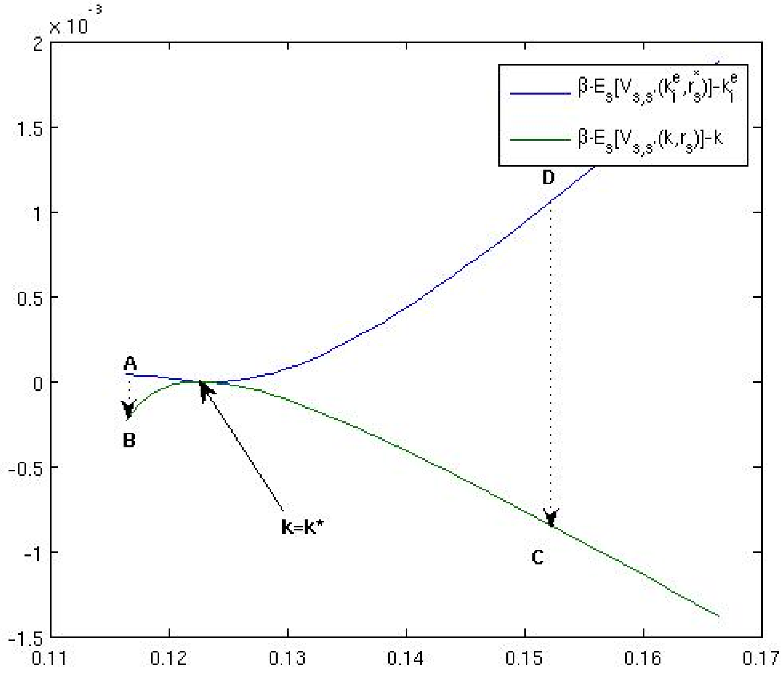
$$NR_{s',s} = 2(1-p_s)\begin{cases} RR & P>1 \\ RR+NC_{s',s} & P<1 \end{cases}$$

$$BR_{s',s} = \int_{x^{\sigma}}^{1}\int_{0}^{1}\left(r_{s'}+k-c-x\left(r_{s'}+\lambda\right)\right)L^e dF_s(x)dF_{s'}(x)$$

D. On the homogeneity of banks capital problem

So far I have characterized the existence and unicity of a solution, under certain conditions, for the optimization problem of representative's bank managers. In the proof of Corollary 1 I have illustrated how the only equilibrium when prices are above its face value is collusive, so that the solution of a central planner and individual banks will coincide. In what follows we, graphically, illustrate the irrelevance of the assumption regarding the existence of a central authority when the economy is in a recession, concluding that capital collusion constitutes, in fact, the only feasible solution for individual bank managers problem. In order to do so, in the following figure I depict, for a given parametrization of the problem, both the difference between expected bank's value and book value of capital (in blue), for a bank holding a capital ratio $k_i \lesseqgtr k_s^*$, and that measure, (in green), when all the banks in the economy hold exactly the same capital ratio, $k_i = k$.

Figure B.1.: *Difference between expected bank's value and book value. Collusive vs non collusive equilibrium*



Recall that under Assumption 1, at each period, the property of bank shares is transferred to a new generation of shareholders, on exchange of a payment equal to book value of capital, only if bank capital is above the regulatory minimum, while those have the possibility to recapitalize the bank through a non dilutory capital injection. Thus, assume that a bank arrives to current state, $s = h$, with a below optimal capital ratio, say (A) in above figure. Bank managers in this situation realize that the expected bank value is above book value of capital, but that increasing capital from there to, let's say, (D) will, in fact, result in a net increase of capital value. However, this will, also, be perceived by each bank manager of the economy, so that all banks will increase their capital up to that point. However, under this new situation, all banks in the economy hold exactly the same level of capital, and there is an aggregate excess of capital, so that given the prevailing interest rate, r_s^*, the true difference between expected bank value and book value will be characterized by point (C).Alternatively, bank managers of the under-capitalized bank could decide to to keep their actual capital level at (A), as this is also profitable. However, if this is the case, bank managers of the other banks decide to increase their liquidity provisioning to the economy, until their capital ratio goes to (A), as that would, also, result in a net increase of capital value. However, under the new situation, again all banks in the economy hold the same capital ratio, and there is an aggregate shortage of capital, which results in real expected losses to all banks, a situation characterized by point (B). In this new situation the marginal value of bank capital will be above 1, and banks will find it optimal to increase their capital ratios.

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Chapter 3.

Market effects of Bond Liquidity: An analysis for the Euro Area

Abstract

"Liquidity: the quality of certain markets/assets that allows market participants to materialize a transaction at a desired moment in time without any of those incurring in further losses due to necessity"

I estimate a modified version of AFNS model, that includes an additional term to account for the existence of a liquidity premium, to real market data on European Government Bonds. That additional term is assumed to depend on time since the bond was initially issued to the market, and then shown to relate with capital evolution. My liquidity measure allows me to characterize the existence of liquidity contagion patterns across European countries, further illustrating the existence of two liquidity differentiated markets within the euro area. The effects of bond liquidity shocks on credit developments is, then, analyzed. Improvements on liquidity conditions lead reductions on credit spreads. The relation between liquidity (capital) and future yields is also presented. Higher liquidity leads to lower future yields. This result is in line with findings on the relation between capital constraints and equity returns evolution, presented in the first chapter of this dissertation. My results post evidence on the paulatine loss of representativity of interbank markets since the burst of the European debt crisis.

Resumen

"Liquidez: la cualidad de ciertos mercados/activos que permite a los participantes en los mercados materializar una transacción en el momento deseado del tiempo, sin que ninguno de ellos incurra en mayores pérdidas por la necesidad"

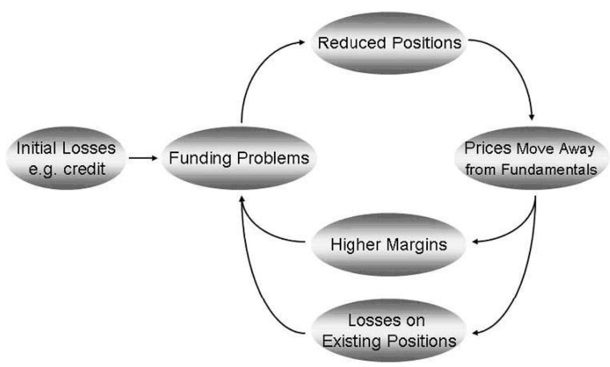
Estimo una versión modificada del modelo AFNS, que incluye un término adicional para acomodar la existencia de una prima de liquidez, a datos reales de mercado de bonos gubernamentales europeos. El término adicional se asume que depende del tiempo transcurrido desde la emisión del bono al mercado, y se muestra que esta medida esta relacionada con la evolución del capital. Mi medida de liquidez me permite caracterizar la existencia de pautas de contagio relacionadas con la liquidez entre los paises europeos, ilustrando la existencia de dos mercados diferenciados de liquidez en la Area del Euro. Los efectos de perturbaciones en la liquidez de los bonos sobre la evolucion del crédito, también son analizados. Las mejoras en las condiciones de liquidez llevan a reducciones en lso spreads de crédito. También se presenta, la relación entre la liquidez (capital) y la rentabilidad futura de los bonos. Mayor liquidez implica menor rentabilidad futura. Este resultado esta en línea con la relación entre las restricciones de capital y la evolución de los retornos en el mercado de acciones, presentada en el primer capítulo de esta disertación. Mis resultados tambien evidencian la paulatina pérdida de representatividad de los mercados interbancarios desde el estallido de la crisis de deuda europea.

3.1. Introduction

The burst of Irish and Greek bond markets, and the subsequent increases of other European bond yields, rose a controversy on whether "contagion" was led by credit or liquidity concerns. Since the early 80's academics and practitioners interest on liquidity implications for asset pricing increased. Miller (1977), highlighted the central role of liquidity to understand price formation in financial markets. Many studies have, since then, remarked the role of liquidity for securities price formation.[1]

Collin-Dufresne (2001) found no evidence of relation between traditional liquidity proxies and credit risk factors, while Duffie, Pedersen, and Singleton (2003), Longstaff, Mithal, and Neis (2005) and Beber, Brandt, and Kavajecz (2009) post evidence in the relation of liquidity and credit as joint determinants of bond prices. A theoretical explanation of the relation between those can be found in Brunnermeier (2008), from which I borrow Figure 3.1, with contagion explained in Kyle and Xiong (2001a), from a wealth perspective, and Acharya, Shin, and Yorulmazer (2013), following a limit arbitrage characterization.

Figure 3.1.: *The two spirals from liquidity*



[1]See Amihud and Mendelson (1986) and Chordia, Roll, and Subrahmanyam (2000)

Portfolio adjustment dynamics are, usually, triggered by initial default shocks. Those lead capital constrained investors to unwind their positions, prices diverging from market fundamentals. That divergence drives subsequent portfolio adjustment processes, due to mark-to-market practices. Those push up funding needs, leading investors to re-balance their entire portfolio. Riskier investments, both in terms of liquidity or credit, are sold with safer investments undertaken. Sold out processes, further, push down market liquidity on more fragile markets, feeding back the process and, potentially, leading to a simultaneous collapse of market liquidity conditions.

From a theoretical point of view, flight-to-quality and flight-to-liquidity phenomena can be distinguished, while their empirical consequences are very similar. Hence, empirically disentangling both actions turns out to be very complex. Furthermore, credit and liquidity are related in both expansions and recessions, while the intrinsic relation between both attributes is amplified by funding scarcity during crisis periods.

The importance of liquidity conditions, for portfolio selection, along with endogeneity concerns, rises un-answered questions on appropriate strategies to identify liquidity. Measurement of liquidity conditions on bond markets has, traditionally, relied on a proxy based approach, such as in Warga (1992) and Boellen and Whaley (1998), while a different econometric approach, based on instrumental variables and modeling dynamics, is presented on Fontaine and Garcia (2012).

Fontaine and Garcia (2012), pairing some carefully selected on-the-run and of-the-run Treasury Securities[2] and using an age related measure, illustrate how changes on liquidity and funding conditions interact for the determination of yields. Linkages between their funding liquidity measure (liquidity premium), the repo market, and shadow banking are established, concluding that "funding conditions have a pervasive and large effect in the determination of interest rates, not only in crisis periods but also in normal times". Their results posts some evidence in favor of Brunnermeier and Pedersen (2009) theoretical model.

My study focuses in the analysis of liquidity implications on European Government Debt Markets. The singular combination of structural and country specific features

[2] See, also, Elton and Green (1998) and Goldreich, Hanke, and Nath (2005)

characterizing those markets, along with recent price developments, makes this an ideal market for a liquidity study. Among relevant characteristics of this market are:

- Funding rules are common, as a common banking authority exists
- There are no currency risks for banks
- No common bond class or debt sharing commitment is present
- Each country bond market is singular due to taxation, market making rules, macroeconomic conditions...
- Liquidity and credit quality are substitutes in this market, as pointed in Beber, Brandt, and Kavajecz (2009)

Two different approaches are present, in the literature, to analyze the pricing of European bonds. Some papers[3] use factor models to study the determinants of yield changes, or yield spreads in the European Market; while others relate changes on European yields with changes in US Treasury yields.[4] Following a similar approach to that presented in Fontaine and Garcia (2012), I recover liquidity conditions of the Euro-Area government bond market through the use of an affine structure model. Then I explore the interrelations of bond liquidity changes, across countries and with other financial markets.[5]

The interrelations between European bond liquidity and other financial markets have been explored in Beber, Brandt, and Kavajecz (2009) and Allen, Carletti, and Gale (2009). The first paper, illustrate how liquidity, CDS spreads and order flow jointly determine flow volumes and yield spreads. They conclude that while liquidity is an important factor to determine volumes invested in the market (and therefore bid-ask spreads), credit concerns are relevant to explain the evolution of spreads

[3]See, for example, Geyer, Kossmeier, and Pichler (2004) and Menkveld, Cheung, and De Jong (2004)

[4]Among others, Codogno, Favero, and Missale (2003), Favero, Pagano, and Thadden (2010), and Ang and Longstaff (2013)

[5]I believe that differences in the use of monetary policy between the ECB and the FED, for the considered period, have distorted the correlation between both markets. The Federal Reserve has performed open market operations, to guarantee the correct transfer of the Monetary policy to the real economy, while the European Central Bank has not been so active. This invalidates a comparison based approach.

across countries.[6] In Allen, Carletti, and Gale (2009) a positive relation between non-hedgeable idiosyncratic liquidity shocks and interbank market volatility, in line with the proposal of Goodfriend and King (1988) is found. Liquidity shocks conduce to interbank market volatility peeks.

My results post evidence on the existence of two liquidity differentiated, but inter-related, bond markets within the Euro-Area. The first one is composed of Core countries, with the second including Peripherals. A further decomposition, to be rationalized in terms of market size is also found. For Core countries, bond liquidity and cash markets are substitutives while this is not the case for Peripherals. Liquidity contagion patterns are identified. The evolution of liquidity on small markets is a leading indicator of future changes of liquidity on big markets. Also, changes of liquidity conditions on big sized core bond markets lead changes of liquidity conditions on Peripherals. This is in line with the existence of a wealth transmission channel of liquidity, as proposed in Acharya, Shin, and Yorulmazer (2013) and Kyle and Xiong (2001b).

While the evolution of liquidity conditions among European countries, and its relation with cash markets is relevant per se, I also analyze the interactions of that and CDS spreads developments. Opposite to several studies[7] were CDS spreads are seen to lead bond liquidity developments, measured through traditional proxies, I find positive liquidity shocks to reduce future credit spreads. This apparent contradiction arises due to a measurement error of liquidity through traditional proxies. A liquidity shock will be reflected on changes of, both, bid and ask price levels. When the difference between those is computed, a part of the liquidity effect is neglected. This is not the case when changes on CDS spreads are considered. Hence, liquidity conditions will appear to affect more CDS spreads, and that measure will lead changes on the proxy variable.

In the next section I present the foundations of my liquidity model along with its calibration. Section 3 presents the data. Section 4 estimation results. In section 5 I conclude.

[6] This is in contrast with Pastor and Stambaugh (2003), where asset prices are found to be related with liquidity risk (understood as the risk of a profound change in liquidity conditions).

[7] See, for example, Pelizzon et al. (2015)

3.2. The model

3.2.1. Theoretical model

I start by stating the affine term-structure model that can be solved for the bond prices irrespectively of the existence of liquidity effects. Assume a Gaussian process for the affine factors of each country $F_{i,c}$, that drive the short rate yield:

$$dF = K(\theta - F)dt + \Sigma dB^{Q} \tag{3.1}$$

where K is assumed to be a diagonal 3x3 matrix. θ, is the long run level of factors, and B^{Q}, is a vector of independent standard Brownian motions under the risk-neutral measure, $\mathbb{Q}$, and Σ is assumed to be a 3x3 diagonal variance-covariance matrix.

$$\sum = \begin{pmatrix} \sigma_1 & 0 & 0 \\ 0 & \sigma_2 & 0 \\ 0 & 0 & \sigma_3 \end{pmatrix}$$

Under those the assumptions, Christensen, Diebold, and Rudebusch (2009), (CDR therein) show that the solution of the above dynamics, for the discount yield function, could be written as:

$$y_t\left(m\right) = a_{c,t}\left(m\right) + \sum_{i=1}^{3} F_{i,c,t}(m)\beta_{i,,c,t} \tag{3.2}$$

with $a_{c,t}\left(m\right)$ the maturity dependent drift[8] and $\beta_{i,c,t}$ the corresponding factor loading at date t, for factor i, and country c:

[8]The expression for the constant, $a_{c,t}(m)$, that guarantees $\theta = 0$, under the risk neutral measure Q, can be found in the appendix of this paper

$$\beta_{1,c,t} = 1$$
$$\beta_{2,c,t} = \frac{(1-e^{-\lambda_1 m})}{\lambda_1 m}$$
$$\beta_{3,c,t} = \frac{(1-e^{-\lambda_1 m})}{\lambda_1 m} - e^{-\lambda_1 m}$$

In addition to assumed dynamics for the short rate, and in line with findings of previous chapter[9], I believe in the existence of a country specific, capital ratio dependent, liquidity premium, $\Psi(k_{c,t})$. Actual capital ratio is the result of capital accumulation on previous period. Hence, actual bond prices would be related with the capital situation at the moment the bond was initially issued and, as a consequence, with the time the bond has been quoted in the market.[10] Thus, I propose the following specification for the determination of bond prices:

$$P^* (F_{c,t}, age_{M,c,t}, L_{c,t}) = \sum_{m=m_1}^{M} D_{c,t}(m) \times C_{c,t}(m) + \Psi(k_{c,t}) \tag{3.3}$$

where $D_{c,t}(m) = e^{-m\left(a_c(m)+b_{c,t}^{\top} F_{c,t}(m)\right)}$ is the discount factor, for a country, c, of any payoff taking place at any date, m. For the functional specification of the liquidity measure, $\Psi(k_{c,t}) = \zeta_c(L_{c,t}, age_{M,c,t})$, I follow Fontaine and Garcia (2012), while the liquidity factor is assumed to affect homogeneously the entire yield curve:[11]

$$\zeta_c(L_{c,t}, age_{M,c,t}) = L_{c,t} e^{\left(-\frac{1}{\kappa_c} age_{M,c,t}\right)} \tag{3.4}$$

[9] The relation between bond prices and capital follows an exponential pattern. See Figure 2.2 for an illustration

[10] The use of a variable related with the time, $age_{M,c,t}$, a bond has been quoted in the market, as an instrument, allows me to avoid endogeneity concerns related with the simultaneous determination of bond portfolio size, bond price and capital holdings. This variable were, initially, found to be relevant for the determination of bond prices in Warga (1992) and Fontaine and Garcia (2012).

[11] This departs from the specification in Fontaine and Garcia (2012). In their model, the liquidity factor loading $L_{c,t}$ is additionally weighted by a maturity specific coefficient, β_M. Parameters, β_M and κ_c, are, then, estimated through the construction of buckets including bonds with similar maturity but different issuance date.

Consequently, the liquidity factor loading, $L_{c,t}$, should be interpreted as the average (base) effect on bond prices of the common liquidity conditions. The country specific parameter, κ_c, tries to capture, in a reduced form, the time decay in the incidence of initial capital conditions for actual bond price determination. If κ_c is positive and equal to two, the relative impact in pricing of liquidity of a just issued bond is a 40% bigger than for those assets that have been in the market for one year.

Assuming an Orstein-Uhlenbeck specification for the evolution of the liquidity factor, $L_{c,t}$, and using a simple Euler discretization for 3.1, leads to the following specification for the dynamics of individual factors (both liquidity and term structure):

$$F_{i,c,t} - \bar{F_{i,c}} = k_{i,c}\left(F_{i,c,t} - \bar{F_{i,c}}\right) + \sigma_{i,c}\epsilon_{i,c,t} \tag{3.5}$$

where k_i is the auto-correlation parameter, σ_i the factor volatility and $\bar{F_{i,c}}$ the long run factor mean.

3.2.2. Model Estimation

The typical approximation to recover term factors is to use bootstrapped forward rates from coupon prices. Unfortunately, that leads to near-exact pricing of the original sample of bond prices which pushes liquidity effects and price idiosyncrasies into forward rates. A classical solution for the over-fitting problem is to exclude bonds with large price discrepancies, relative to their neighbors.[12] However, this procedure removes any evidence of liquidity effects, thus being unfeasible for liquidity identification purposes.

Hence, instead of estimating our model on rates, or introducing potential selection bias by an ad hoc selection procedure I decide to use un-smoothed fixed coupon bond prices, and an unbalanced price panel, for the estimation of my state space model. The formal representation of that is:

[12] See Fama and Bliss (1987) for further details

$$
\begin{aligned}
F_{c,t} - F_c &= K_c \left(F_{c,t} - F_c\right) + \Sigma \epsilon_{c,t} && (3.6)\\
P_t &= \phi \left(F_{c,t}, C_{c,t}, age_{c,t}\right) + \Omega \theta_t && (3.7)
\end{aligned}
$$

where K_c is a $4x4$ diagonal autorregresive coefficient matrix, ϕ a $nx1$ vector of estimated prices resulting from 3.3. Σ is the 4x4 diagonal variance-covariance matrix of factors and Ω the nxn diagonal covariance matrix of pricing errors. To simplify the estimation of Ω, a linear maturity dependent specification for the individual elements of that matrix is proposed:

$$
\Omega_n = \omega_0 + \omega_1 M_n \tag{3.8}
$$

3.6 fully characterizes factor dynamics and 3.7 measurement dynamics. System estimation involves 16 parameters in a non-linear framework. Non-linearity results in technical difficulties with traditional estimation methods which leads me to the use of Unscented Kalman Filter (UKF) methodology, introduced by Julier and Durrant-Whyte (1995).[13]

The UKF is more accurate, for the estimation of term structure models, than the traditional Extended Kallman Filter,[14] while presents the advantage of not requiring analytical derivatives for its computation. Moreover, the estimation of model parameters can be made via likelihood function maximization, under a QML framework.[15] That likelihood function could be written as:

$$
L\left(\omega\right) = \sum_{t=1}^{T} l\left(P_t; \omega\right) = \sum_{t=1}^{T} log\left(\Phi\left(P_{t+1,t}, \Omega_{t+1,t}; \omega\right)\right) \tag{3.9}
$$

[13]The description of such filtering methodology falls beyond the scope of this document and, so, we refer to the textbook of Wan and Merwe (2002) for its full discussion.

[14]See Christensen, Diebold, and Rudebusch (2011)

[15]For further details see Fontaine and Garcia (2012)

where $\Phi(\cdot)$ is the multivariate Gaussian density, and $(P_{t+1,t}, \Omega_{t+1,t})$ the, one period ahead, prediction of prices and mean squared errors (MSE).

The structure of the model, characterized on equations 3.6, 3.7 and 3.8, require imposing some parametric restrictions. To guarantee stationarity, the elements in the autorregresive matrix, K_c, must remain within the unit circle, while κ_c and λ_1 must be positive. Additionally, a non-linear restriction to the second covariance contour is imposed, to guarantee non-negative instantaneous interest rates.[16]

A fundamental concern with the proposed methodology relates to the consistency of Unscented Kalman Filter parameter estimates, when using unbalanced panel data. This problem, has been recently studied by Pancost (2013), for an unbalanced sample of US treasury bond prices. At least for that case, the introduction of an age related factor, improves asymptotic distribution of errors, leading to consistency of estimates.

3.3. The Data

In this study, I use a weekly sample of sovereign bonds, for a set of European Countries.[17] From the complete sample of references I dropped floating coupon, stripped and zero coupon bonds. I also drop bonds with special characteristics, as early redemption or call-ability. Therefore, only fixed coupon bonds are considered, to obtain an ex-ante liquidity homogeneous database. Finally, bonds with a residual maturity of less than one year, more than 30 years, or whose initial maturity was above 50 years are also dropped.

The sample period starts in January 2007 and ends in December 2011. Data then includes $95,456$ observations, on 12 countries, and 261 weeks. Information on coupon rates, payment frequency and maturity dates, joint with end-of-week clean prices in

[16] In the equilibrium no restriction is binding and the estimation is performed in two steps, using Matlab. An initial parameter estimation is obtained, using monthly data, the fmincon optimizer and multiple starting parameters. Then, those estimations are used as an initial guess for the weekly calibration. The BFGS numerical approximation to the hessian matrix using fminunc routine is then used to identify the variance-covariance matrix, Ω.

[17] Deutschland, France, Italy, Spain, Austria, Belgium, Netherlands, Ireland, Portugal, Finland and Greece within the Euro Area and Switzerland as a Non-Euro country

USD are recovered from Datastream, for each reference. From that information, I compute coupon bond prices. Additionally, first issuance date information is used to construct the age variable, in years.

Reference yields for the 1, 2, 3, 4, 5, 6, 7 and 10 year maturities and 5 year CDS spreads in USD (when available), are collected, for each country, from Datastream. Time series data of the Eurostoxx Volatility Index (VSTOXX), Eurostoxx 600 Banking Index Market to Book Value ratio, Eonia rates, Euribor rates and 1, 2, 5 and 10 years IRS rates, are also obtained from the same source. Data on bond borrowing comes from Markit DataExplorers database. That includes, for each reference and day, information on average lending (repo) fees for different time horizons.[18]

As my sample period only cover a crisis, results are subject to critique due to the existence of selection bias. While data on prices could be expanded to a previous year, that is not possible for other series. An increase of the sample size to a more recent year is, also, problematic. In this case, market actions by the ECB would have modified existing relations between bond prices, making estimates unrepresentative. Thus, following results should not be understood to be representative of long run structural relations but, rather, interpreted in terms of what happens during recessions.

3.4. Estimation Results

Table 3.1 presents Kalman filter estimates for model parameters under the proposed methodology, with p-values in parenthesis. Results are presented for each country but Deutschland. For this last country, liquidity estimates are not significant, at any confidence level. This is consistent with the benchmarking role of Deutschland Debt, and allow to interpret the liquidity factor in relative terms.

The liquidity factor (along with the traditional ones), is significant for all the considered countries, at least at a 10% level. However, great variation on estimates for the

[18]Descriptive statistics can be found in appendix to this document

Table 3.1.: *Unscented Kallman Filter estimates of the Term Structure Affine Model with Liquidity*

	$F_{1,c}$	$k_{1,c}$	σ_1	$F_{2,c}$	$k_{2,c}$	σ_2	$F_{3,c}$	$k_{3,c}$	σ_3	L_c	$k_{L,c}$	σ_L	κ	ω_0	ω_1
AT	0.150***	0.969***	0.0197***	-0.1344***	0.1026***	0.0143***	-0.1771***	-0.7206***	0.276***	-0.004***	0.9741***	0.0021***	1.5474***	0,0024***	0,0033***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
BE	0.1871***	0.9697*	0.0032**	-0.1769*	-0.0019*	0.0003**	-0.2254*	-0.9879**	0.2985*	-0.0628**	0.9143***	0.0018*	2.9943*	0,0139**	0,0001*
	(0.0093)	(0,0521)	(0,0185)	(0,0786)	(0,0839)	(0,0140)	(0,0858)	(0,0424)	(0,0715)	(0,0277)	(0,0010)	(0,0561)	(0,0600)	(0,0457)	(0,0502)
CH	0.0287*	0.9696**	0.0016***	-0.018*	0.0468**	0.0102**	-0.0227*	-0.4998**	0.0002**	-0.0238**	-0.2166*	0.0004*	2.9992*	0,0094*	0,0086**
	(0,0957)	(0,0407)	(0,0084)	(0,0990)	(0,0652)	(0,0532)	(0,0769)	(0,0247)	(0,0290)	(0,0371)	(0,0892)	(0,0713)	(0,0702)	(0,0820)	(0,0133)
ES	-0.3933**	0.7673**	0.0068*	-0.3226**	-0.0162***	0.3032*	-0.1113**	-0.8881**	0.0025**	-0.0042**	0.4547***	0.0041***	0.5196**	0,0002**	0,0014**
	(0.0152)	(0,0393)	(0,0927)	(0,0109)	(0,0000)	(0,0521)	(0,0265)	(0,0306)	(0,0478)	(0,0432)	(0,0485)	(0,0000)	(0,0193)	(0,0499)	(0,0306)
FI	0.2188***	0.8957***	0.0016**	-0.1807***	0.2078***	0.0627**	-0.0813***	-0.0194**	0.0265**	-0.0048**	0.7826***	0.0028***	2.1896***	0,0022***	0,0029**
	(0.0000)	(0,0000)	(0,0115)	(0,0091)	(0,0000)	(0,0285)	(0,0005)	(0,0438)	(0,0134)	(0,0428)	(0,0000)	(0,0000)	(0,0000)	(0,0000)	(0,0171)
FR	0.3125*	0.9892**	0.0038*	0.3243**	0.0283***	0.4641*	-0.3782***	-0.394**	0.4429**	-0.0533*	0.9673**	0.0017**	2.9954*	0,0100*	0,0000**
	(0,0769)	(0,0184)	(0,0672)	(0,0110)	(0,0015)	(0,0740)	(0,0035)	(0,0447)	(0,0331)	(0,0922)	(0,0231)	(0,0136)	(0,0678)	(0,0852)	(0,0252)
GR	0.045**	0.9932**	0.0025*	-0.0226**	0.8483**	0.0089*	-0.0004*	-0.003**	0.0856*	-0.0138**	0.1836*	0.0016*	1.0605*	0,0127*	0,0143**
	(0,0428)	(0,0330)	(0,0963)	(0,0245)	(0,0145)	(0,0739)	(0,0978)	(0,0153)	(0,0842)	(0,0104)	(0,0588)	(0,0995)	(0,0729)	(0,0878)	(0,0189)
IE	0.0552**	0.9660***	0.0024**	-0.0371**	0.0488***	-0.0149**	-0.0144**	-0.2265**	0.009**	-0.0027**	0.9891**	0.0009**	0.6358**	0,0026**	0,0033**
	(0.0208)	(0,0000)	(0,0141)	(0,0114)	(0,0000)	(0,0368)	(0,0355)	(0,0398)	(0,0454)	(0,0467)	(0,0192)	(0,0437)	(0,0151)	(0,0208)	(0,0275)
IT	0.0496***	0.9678**	0.0022**	-0.0378**	0.0016***	0.0198**	-0.0165**	-0.9328**	0.0003**	-0.0053**	0.9228**	0.0051**	2.996**	0,0025**	0,0034**
	(0.0002)	(0.0224)	(0,0382)	(0,0226)	(0,0000)	(0,0395)	(0,0392)	(0,0119)	(0,0498)	(0,0496)	(0,0362)	(0,0438)	(0,0321)	(0,0207)	(0,0332)
NL	0.7635***	0.9285***	0.0020***	-0.2959***	0.0603***	0.9328***	-0.2323***	-0.2186***	0.0283***	-0.0001***	0.9529***	0.0013***	2.5471***	0,0030***	0,0037***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
PT	0.5054**	0.995*	0.0043*	-0.3438*	0.6223*	0.4829*	-0.0877***	-0.002*	0.0630*	-0.0099*	0.9755***	0.0002**	0.575**	0,0011*	0,0039**
	(0,0318)	(0,0548)	(0,0968)	(0,0742)	(0,0977)	(0,0779)	(0,0096)	(0,0587)	(0,0769)	(0,0628)	(0,0009)	(0,0349)	(0,0396)	(0,0806)	(0,0242)

p-values in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

decay parameter, κ_c, and on the impact of the liquidity factor on prices, is found. For all Euro-Area countries, age has a positive effect on prices. Older bonds are overpriced compared to new issuances. This is consistent with a period of capital deterioration. Estimates suggest the existence of two differentiated liquidity markets within the euro-area: Core countries and Peripherals. A full characterization of which country belongs to each category could be found in Table 3.3.

The average impact of liquidity is high and very persistent for Belgium and France. For Belgium new references have a lower price of 6.28$ than their peers. For France the discrepancy is of 5.33$. This is in line with the deterioration of their banking systems, that led to the restructuring of some banks, like Dexia and Credit Lionnays. Average effect for the remaining core countries is much smaller and amounts, on average, to 0.29$ while for peripherals the effect is of 0.83$.

Estimates on the decay parameter, also, highlight the differentiation of countries within Euro Area. Peripheral countries (Spain, Italy, Portugal and Greece) exhibit low decay parameter values. An average value of 0.69 is estimated. Roughly speaking, each year since issuance reduces the impact of liquidity on prices in a 75%. Core countries, in contrast, exhibit an average decay parameter value of 2.54, equivalent to a reduction of 33%, per year, on the effects of capital. While the effect of capital on peripherals bond prices reflect a high exposure to shocks, liquidity on core countries is a structural factor.

High persistence of liquidity effects on core country prices, when compared to peripherals, could be rationalized in terms of convergence trading. According to theoretical findings in Acharya, Shin, and Yorulmazer (2013), arbitrageurs belonging to different, but integrated, economies holding different capital levels and risk exposures, will buy assets in that economy for which returns are higher. Thus, relative liquidity will be, apparently, above expected in riskier markets. However, market returns (yields) will be always above those of less risky countries.

While Switzerland does not belong to the Euro-Area, I incorporate that country to get a confirmation (limited) on the relation between my liquidity measure and banking capital. As expected, the liquidity factor has a positive impact on prices for this country, while decay parameter value is similar to that of Core Countries. This is in line to the perception of Switzerland as a capital unconstrained economy.[19]

Figure 3.2, present the evolution of liquidity for each country.[20] That provides further evidence on the linkage of bond prices with capital and banking crises. The cases of Ireland, Portugal and Greece are, by obvious reasons paradigmatic. Deep differences, among the economic conditions of those countries exist, while their graphs illustrate the relevant effects of banking crisis in government bond liquidity conditions.

For Ireland, a sharp reduction of liquidity conditions followed the revelation of financial difficulties of Allied Irish Bank and Bank of Ireland. Those difficulties, led to the issuance of state guarantees on September 2008. A similar pattern is observed for Portugal, in the period 2008-2009, after the crisis of "Banco Portugues de Negocios", also bailed out by the government.

The case of Greece reveals both, the linkage between bond prices and banking funding costs and the effect of a government bail-in by supranational authorities.[21] A sharp reduction in liquidity conditions followed the rating downgrade by S&P, in

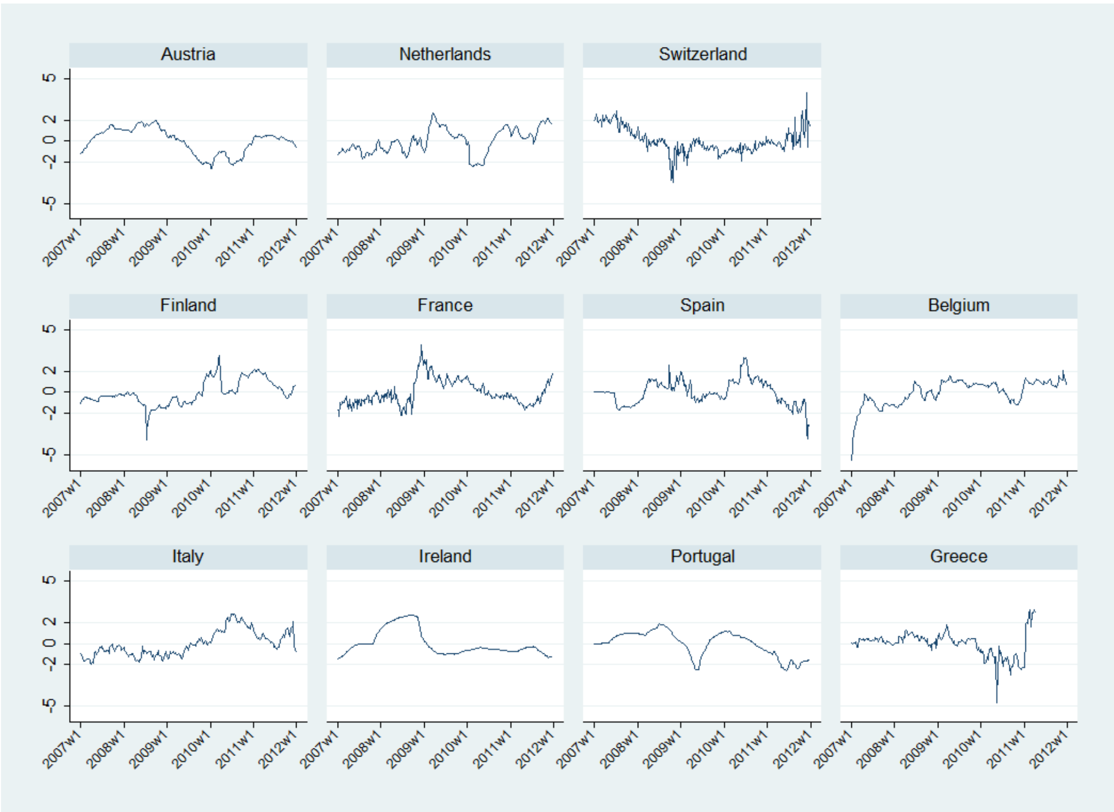
[19]Further evidence on the linkage between liquidity and bank capital is provided on next sections

[20]Liquidity is presented in normalized terms. Changes, then, should be interpreted as significant deviations from its structural level.

[21]Computation of the liquidity factor for Greece ended on April 2011. From that date, covariance matrix becomes singular. This suggests an structural change in the relation between bank capital and bond prices, likely to derive from debt restructuring negotiations

April 2010, to non investment grade. That, excluded Greek debt as an eligible collateral in financing operations conducted by the ECB. A sharp recovery of those conditions took place after the central bank decided to relax debt eligibility conditions, granting the access of Greek banks to financing operations, in May. The start of debt restructuring negotiations between Greece and the Troika drove a big increase in the impact of liquidity on prices at the beginning of 2011.

Figure 3.2.: *Evolution of the Standardized Liquidity Factor by Country*



3.4.1. Spill-over effects of liquidity across European countries

Predictive regressions of each standardized country liquidity factor using other countries lagged liquidity factor, are performed.[22] Results, for a one week prediction horizon[23] are presented in Table 3.2. Those illustrate the existence of liquidity spill-over effects across European debt markets.

Table 3.2.: *Spill-over effects of the liquidity factor, 1 month horizon*

	AT	NL	FI	FR	BE	IE	ES	GR	IT	PT
L.AT	0.990***	0.0220***	-0.0256***	-0.0530***		-0.0128***	-0.0862***	0.172***		-0.0317***
	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)		(0.000)
L.FI	0.0387***	-0.0280***	0.931***		0.0193***	0.00666***	0.0141**	0.0858***	0.00807**	-0.0200***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.014)	(0.000)	(0.012)	(0.000)
L.FR	-0.0300***	0.0283***	0.0103***	0.887***		-0.0386***	0.0280***	-0.0394***	-0.0168***	-0.0172***
	(0.000)	(0.000)	(0.002)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L.BE	-0.0141***	-0.0463***	-0.0237***	0.0439***	0.916***	0.00573***	-0.00714**	0.0839***	0.0472***	0.00670***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.010)	(0.019)	(0.000)	(0.000)	(0.004)
L.IE	0.00396		-0.0204***	0.0315***	-0.0229***	0.994***	0.156***	-0.115***	-0.0436***	
	(0.358)		(0.000)	(0.010)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
L.ES	0.0142***	0.0489***	-0.0178***		0.0401***	-0.0224***	0.882***	0.0693***	0.0241***	-0.0236***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L.GR	-0.0171***	0.0362***		-0.0511***		0.00169	-0.0479***	0.788***	-0.0358***	
	(0.000)	(0.000)		(0.000)		(0.107)	(0.000)	(0.000)	(0.000)	
L.IT	-0.0356***	0.0548***	0.0390***	-0.0871***	-0.0426***	-0.00617***		-0.129***	0.921***	-0.00926***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.009)		(0.000)	(0.000)	(0.007)
L.PT	-0.00770**	-0.0357***	0.0287***		-0.0262***	0.0146***	-0.132***		0.0212***	1.006***
	(0.029)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)		(0.005)	(0.000)
L.NL		0.965***	0.0263***	0.0297***	0.0196***		-0.0896***		-0.0124**	
		(0.000)	(0.000)	(0.000)	(0.000)		(0.000)		(0.011)	
Observations	2441	2441	2811	2441	2811	2441	2441	2431	2441	2811

p-values in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

According to the theoretical model in Acharya, Shin, and Yorulmazer (2013), substitution effects are likely to drive the evolution of closely related markets when capital constraints are absent, while capital constraints are likely to lead to liquidity contagion through the wealth channel. The degree of economic integration will also be relevant. The greater the degree of interrelation between two countries, the greater the size of the regression coefficient should be.

[22]Endogeneity is mitigated by including a lagged version of the predictive liquidity factor. Newey-West robust standard errors considered for p-values computation

[23]Similar results are presented in Table A.1 and Table A.2 for alternative horizons

Hence the following convention is set. Contagion effects will exist whenever the regression coefficient is positive. Increases (reductions) in the liquidity premium, for a country, translate into future increases (reductions) in the liquidity premium for another country. Substitution effects will exist whenever the regression coefficient is negative.

Regression results on Table 3.2 reinforce the existence of two differentiated liquidity markets within the euro-area. That general categories can, further, be splitted on two additional sets. Those two, approximately, correspond to a size categorization. This categorization is presented in Table 3.3.

Table 3.3.: *Countries by category*

	Big Market	Small Market
Core countries	France, Belgium	Austria, Netherlands, Finland
Peripherals	Spain, Italy	Greece, Portugal, Ireland

Within each general category, liquidity conditions of smaller countries are leading indicators (and thus contagion between countries exist) of price changes on bigger bond markets. Liquidity shocks affect quicker to more illiquid markets. Changes on liquidity conditions on Spain (Belgium) lead changes on liquidity conditions on Italy (France). Contingent on the prediction horizon (one week, two weeks or one month), one standard deviation of the liquidity premium for Spain translates in a future increase of 0.024 (0.0531 or 0.0818) standard deviations in the liquidity premium of Italy. For Belgium, the same increase, leads to predicted increases of 0.0439 (0.0699 or 0.0626) on France liquidity. For smaller bond markets, similar results are found.

Aggregate contagion effects are present when considering the effect of big core country liquidity shocks on peripherals liquidity. This points towards the existence of a wealth channel for liquidity transmission. As bond prices, in core countries, increase, due to funding liquidity, mark-to-market practices increase holders wealth. The increase in wealth lead to portfolio re-balance (diversification) and price increases on peripheral bonds.

A flight to liquidity is, also, observed within regions. Aggregate substitution effects to Italy (Spain) are observed in the predictive regressions of Ireland, Greece and Portugal. One standard deviation increase in the liquidity premium of Spain and Italy, translate on aggregate reductions of the liquidity premium of 0.03 (0.05 or 0.09) standard deviations for the Irish case, of 0.05 (0.04 or 0.08) for the Greek case and of 0.03 (0.06 or 0.12) for Portugal. Similar effects are also in place for the case of Belgium and France and smaller core countries.

Overall, those effects point in the appropriate direction to validate the theoretical model presented in Acharya, Shin, and Yorulmazer (2013).

3.4.2. Liquidity and bond excess returns

Liquidity effects extend to the predictability of bond excess returns. Those are defined as the difference between the benchmark yield and the Euribor interest rate, for the prediction horizon. Results on the capacity of the liquidity measure to predict bond excess returns, on different horizons, are shown in Table 3.4. As discussed in Fama and Bliss (1987), Campbell and Shiller (1991) and Cochrane and Piazzesi (2005), for the case of US treasuries, term structure factors are incorporated, to control for the information content on forward rates.

Table 3.4.: *Bond Excess Returns and Liquidity*

	1Y YIELD	2Y YIELD	3Y YIELD	4Y YIELD	5Y YIELD	7Y YIELD	10Y YIELD
3 Months	-0.546***	-0.571***	-0.574***	-0.561***	-0.535***	-0.467***	-0.401***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.003)
6 Months	-0.556***	-0.557***	-0.547***	-0.526***	-0.498***	-0.431**	-0.343**
	(0.007)	(0.005)	(0.006)	(0.007)	(0.009)	(0.016)	(0.036)
12 Months	-0.336*	-0.306	-0.276	-0.247	-0.219	-0.164	-0.0887
	(0.078)	(0.100)	(0.128)	(0.162)	(0.202)	(0.301)	(0.521)
R^2 3 Months	0.285	0.308	0.313	0.312	0.310	0.302	0.286
	(0.223)	(0.246)	(0.254)	(0.258)	(0.260)	(0.260)	(0.253)
$R^2$6 Months	0.250	0.263	0.265	0.266	0.267	0.267	0.258
	(0.188)	(0.205)	(0.213)	(0.219)	(0.224)	(0.232)	(0.233)
R^2 12 Months	0.134	0.149	0.160	0.172	0.186	0.217	0.248
	(0.115)	(0.134)	(0.148)	(0.162)	(0.178)	(0.212)	(0.247)

p-values in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In line with findings in Fontaine and Garcia (2012), the liquidity factor presents high predictive capacity. The upper part of that table presents regression results of our liquidity premium on future (annualized) excess returns for 3, 6 and 12 month horizons and maturities ranging from 1 to 10 years. In the lower panel, adjusted R-squared results are presented, including and excluding (between braces) my liquidity factor.

Estimates are negative, and significant, for all maturities up to a 6 month horizon. A one standard deviation shock to liquidity produces an impact on excess returns that ranges from 54 to 40 bps, in 3 month predictions, and from 55 to 34 bps, on 6 month predictions. R-square measure, for the same horizons, ranges from 28.5% to 31.5% for the shorter and from 25% to 26.7% for the longer horizon.

Results excluding the liquidity factor illustrate that, on an average, a 20% of total predictive power is due to that factor.[24] Next, in order to grant the validity of my factor as a true indicator of funding liquidity conditions I analyze the relation between that and real repo rates.

3.4.3. Liquidity and lending (repo) market

DataExplorers data on lending comprises daily information on lending rates, borrowed amounts and total lending capacity, by reference, for the full span of countries, at a daily frequency. A value weighted average lending fee, for each instrument, is available at weekly and daily frequencies. That data is aggregated, to construct a country specific indicator, making use of transaction quantities for each reference, and annualized weekly fees. Excess funding costs on repo transactions are, then, computed, for each prediction horizon, as the difference between lending fees and their respective riskless rates.[25]

[24] Even though this results seem relevant, one concern is that model misspecification would lead to estimates of the term structure factors that do not correctly capture the information content of forward rates inducing spurious correlation between liquidity and excess returns. However, absence of a unified database at a Euro level on forward rates does not allow us to perform a formal test of this hypothesis.

[25] For prediction horizons below one year, Euribor rates are considered. For longer horizons, rates are computed via bootstrapping methodology on 6 month IRS rate curve.

Concerns with lending data relate with the fact that pure funding operations cannot be separated of those performed for speculative purposes. Typical repo contracts do not specify the necessity to disclose the objective of a repo (lending) transaction. Potentially any repo transaction could be conducted with speculative purposes. Another concern arises due to the existence of "specials" and "reference bonds". The effect of "specials" and "reference bonds" on repo market transactions is well documented in the literature. It will lead to an increase in the perception of overall liquidity within a market, concentrating transactions at relatively lower rates.

Those concerns would translate into the existence of measurement errors on lending rates. However, the amount of references for each country, helps keep measurement error at a low level, when weighted averages lending fees are considered.

Predictive regressions, for different horizons, of the liquidity factor on excess funding costs are then conducted. Country fixed effects panel regressions include term structure factors to control for forward rate effects, while Newey-West standard errors are used to report p-values.[26] Results are shown in Table 3.5.

Table 3.5.: *Repo market Excess Funding Costs and Liquidity*

	3 Months	6 Months	9 Months	12 Months	24 Months
LIQUIDITY	-0.0991*	-0.126**	-0.155**	-0.172**	-0.209*
	(0.078)	(0.042)	(0.025)	(0.020)	(0.064)
Adjusted R^2	0.001	0.004	0.008	0.010	0.010

p-values in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Regression results are conclusive, and illustrate the existing relation between our measure and funding conditions in the bond market. A negative relation between that and excess funding cost is present, for all prediction horizons, a maximum predictive capacity obtained for a twelve month horizon. This is in line with the theoretical relation between liquidity risk and funding costs. As bond liquidity risks reduce, lenders would be more prone to accept those as collateral on their funding

[26]Estimates of term structure factors are dropped from regression results shown in Table 3.5.

operations. Consequently, lending fees should reduce along with excess funding costs.

The effect of the liquidity factor, on predicted repo excess funding cost, is increasing with time. This is in line with a period of reducing riskless interest rates, and increasing cash needs by financial entities. The effect of our liquidity measure ranges from 9 to 20 bps, for 3 months and 24 months prediction horizons, with an average daily excess funding cost of 46 bps and wide dispersion by country.[27]

The significance of the liquidity factor, as a predictive measure of excess funding costs, illustrates the structural nature of liquidity. This is in line with findings in Jordan and Jordan (1997), Buraschi and Menini (2002) and Cherian, Jacquier, and Jarrow (2004), for the US market, and provides evidence of absence of misspecification for the proposed model.

3.4.4. Liquidity and the CDS market

Effects of liquidity extend to the CDS market. As discussed in Brunnermeier (2008) and Brunnermeier and Pedersen (2009), linkages between credit and liquidity are likely to arise due to mark-to-market practices. Asset sell offs will follow credit shocks, while portfolio re-balance will reduce asset prices, increasing liquidity risks in the short run. In the long run, however, average credit spreads will not be affected by liquidity portfolio composition determined by fundamental characteristics.

While a pure credit product, like a CDS, should not theoretically include liquidity effects. The use of bootstrapping techniques on observed bond prices, to recover CDS spreads, would attribute changes on liquidity conditions to credit shocks. This creates, yet, another linkage between short term evolution of CDS spreads and liquidity conditions.

To analyze the existence of such spurious relation between CDS and liquidity conditions, the predictive capacity of my liquidity factor for CDS spreads is presented, at a panel data level,[28] and for different horizons, on Table 3.6. As on previous sec-

[27] The liquidity factor is relevant for Austria, Belgium, Spain and Italy and regression results by country are available upon request.

[28] Country specific regressions are available upon request

tions, term structure factors are included to control for the existence of forward rate effects while Newey-West robust standard errors are used for p-values computation.

Table 3.6.: *Contagion of Liquidity effects to the CDS market*

	3 Months	6 Months	9 Months	12 Months
LIQUIDITY	-0.433***	-0.385**	-0.284*	-0.211
	(0.009)	(0.028)	(0.095)	(0.215)
LEVEL	0.733***	0.835***	0.845***	0.683**
	(0.000)	(0.000)	(0.002)	(0.026)
SLOPE	0.381**	0.130	-0.0263	-0.181
	(0.021)	(0.382)	(0.850)	(0.230)
CURVATURE	-0.472**	-0.413**	-0.106	0.287**
	(0.015)	(0.029)	(0.452)	(0.039)
R^2	0.304 (0.252)	0.271 (0.233)	0.174 (0.154)	0.111 (0.098)

p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

As expected, our liquidity measure is significant for the shorter horizons of 3 and 6 months, so that a one standard deviation shock in liquidity reduce CDS spreads of 43.3 and 38.5 bps respectively, on average. The lower part of the table reports adjusted R-squared measure, with and without (between parenthesis) including the liquidity measure.

The importance of liquidity, as a predictor of developments in the CDS market, reduces with the prediction horizon. Its explanatory power amounts to a maximum of 5.2% for the shorter horizon and only to a 2% when 9 month predictions are considered. This highlights the diffusing effect of liquidity on credit spreads with time. In the long run, CDS spreads truly reflect default probabilities while funding constraints affect credit spreads, in the short run, via liquidity conditions. This validates the theoretical model in Brunnermeier and Pedersen (2009).

3.4.5. Liquidity and Bank's Market to Book Value measure

Now, I turn to the analysis of the interactions between bond liquidity and other non bond markets. I start analyzing the relation between liquidity and bank capital. An implication of bond pricing models[29], arbitrage models[30] and bank capital models,[31] is that wealth (bank capital) effects will work as a transmission mechanism of shocks across markets. Reductions on bond liquidity will translate into lower banking ratios and, mechanically, higher market-to-book value ratios.

Measuring wealth of an economy is a challenging task. A widespread convention, when characterizing the inter-temporal evolution of wealth within an economy, is to use the evolution of its GDP as a proxy, while a wide diversity of magnitudes to measure aggregate wealth, like total assets, cash balances and other monetary measures are traditionally used. In the modeling section of this chapter, the inclusion of a liquidity factor, related with the time a bond has been quoted in the market, has been justified to be a proxy of funding conditions. Evidence on the validity of such perception is, now, presented.

Table 3.7, present results of predictive regressions on the value of Eurostoxx 600 Market to Book Value Banking Index and country liquidity factors. Term structure variables are included to control for forward rate effects, the VStoxx volatility Index is included to control for aggregate equity risks, and a lagged values of the index to control for endogeneity. Overall, regressions take the form:

$$I_{t+h} = \alpha + \sum \beta_c L_{c,t} + \theta X_t + \vartheta I_t + \omega V_{t+h} + \epsilon_{t+h}$$

Where X_t corresponds to the vector of term structure variables, V_{t+h} is the value of the volatility index, I_t the lagged value of the market-to-book value index, and $L_{c,t}$ to the standardized value of the liquidity factor for country c at moment t. Regressions are conducted at levels, rather than for variations, as book value magnitudes follow

[29] See Kyle and Xiong (2001a)
[30] See, for example, Kondor (2009) and Acharya, Shin, and Yorulmazer (2013)
[31] See previous chapter

a slowly varying pattern. If, instead, returns were considered any liquidity effect would be, mathematically, cleared off the market.

Table 3.7.: *Funding Liquidity and Eurostoxx 600 Bank's Market to Book Value Ratio*

	3 Months	6 Months	9 Months	12 Months
BELGIUM	-0.0134***	-0.0524***	-0.0903***	-0.0758***
	(0.002)	(0.001)	(0.000)	(0.000)
FRANCE	-0.0108***	-0.0569***		
	(0.000)	(0.003)		
IRELAND	-0.0879***	-0.130***	-0.124***	-0.0842**
	(0.000)	(0.000)	(0.000)	(0.033)
ITALY	-0.0477***	-0.0840***	-0.119***	-0.112***
	(0.000)	(0.000)	(0.000)	(0.000)
PORTUGAL	-0.0241***	-0.0870***		
	(0.000)	(0.004)		
α	0.203	0.402***	0.651***	0.823***
	(0.124)	(0.007)	(0.000)	(0.000)
R^2	0.950	0.935	0.881	0.773

p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

A clear pattern emerges from results, once non significant variables are dropped. The evolution of the market-to-book value ratio is, in general, determined by liquidity conditions on countries facing banking crisis during the considered period. Liquidity of Italian Bonds is also relevant. This last fact, reflects, the importance of Italian bonds for domestic banks' portfolio composition,[32] which makes those more exposed to changes on bond liquidity conditions.

The relation between liquidity variations and market-to-book value is negative, as expected. When liquidity conditions are above its long run mean, market-to-book value is found to increase less than expected. This relation validate my perception on the close evolution of funding and liquidity conditions, and arises due to the

[32] According to data from ECB, 40% of Italian banks' bond portfolio correspond to Italian Government Bonds.

increase of book values.[33] R-squared values illustrate the capacity of liquidity factors to explain changes on market to book value ratios. That measure oscillates between 95% for the 3 months horizon to 77.3% for one year predictions.

Unexplained market to book value ratio changes range from 20.3%, for 3 months prediction horizon, to 82.3% for yearly computations. The higher impact on market-to book value changes are due to deviations of liquidity conditions on Ireland. Among European countries, that one suffered the deepest banking crisis, most of its banking system including the two biggest banks (Anglo-Irish and Bank of Ireland) required capital injections, lately coming from external institutions.[34] Roughly speaking, one standard deviation shock to this factor leads to unexpected reductions of the market to book value of 13% to 8%, depending on the prediction horizon.

Greece liquidity factor is found not to have, statistically significant, impact on the evolution of capital (funding) conditions. This relates to the fact that , opposite to other European crises, Greek crisis is founded on credit rather than on liquidity concerns. It also posts evidence on the low representativity of that banking system at a European scale.

3.4.6. Liquidity and Cash Markets

I end up the characterization of the effects of bond liquidity conditions, with an analysis of the relation of that conditions and cash markets. Over the considered period a decline in the activity of the interbank market took place. That relates to concerns on banks resilience. Resilient banks (core country banks) holding excess cash positions have, over the period, restricted their activities in the interbank market, to gain protection against unexpected default by potential borrowing banks (peripheral banks). A declining relation between Euribor rates and liquidity conditions of peripheral banks is, hence, likely to exist over my sampling period.

Table 3.8 illustrate the existence of such evolution for a three month prediction

[33] While book value is dependent on past performance, market value is an expectational measure. Hence, unpredicted deviations of liquidity from its long run mean will just affect book values and not market values.

[34] As a consequence Debt-to-GDP ratio increased from 45% to 106% on the 2008-2011 period.

horizon and Euribor 3 month loans[35]. Instead of relating the Euribor rates to our liquidity measure, an excess return variable is computed, as the difference between the relevant term Euribor rate and Eonia. Therefore, excess returns represent the term risk premium a bank will receive by lending money to private sector at a long term floating rate and financing those loans daily in the interbank market.

Table 3.8.: *Liquidity effects on 3 month Euribor*

	2007-2011	2007	2007-2008	2007-2009	2007-2010
AUSTRIA	0.0691**		0.175***	0.0775*	0.115***
	(0.010)		(0.006)	(0.098)	(0.008)
IRELAND	0.117***	-0.696***	0.164***	0.209***	0.110***
	(0.002)	(0.000)	(0.001)	(0.000)	(0.006)
BELGIUM		0.0730***			
		(0.002)			
SPAIN		0.205**			
		(0.038)			
NETHERLANDS		0.418***	-0.276***	-0.118***	
		(0.000)	(0.001)	(0.008)	
PORTUGAL		1.992***		-0.188***	
		(0.000)		(0.000)	
GREECE				0.198***	
				(0.006)	
ITALY				0.244***	0.0678**
				(0.000)	(0.043)
Adjusted R^2	0.381	0.826	0.578	0.506	0.500

p-values in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The first column of that table shows whole sample period results with additional columns presenting rolling regressions for 2007 to 2010 period including one additional year in each. A reduction in the explicative capacity of our liquidity measure, as measured by R-square, and the number of country liquidity premiums related to excess returns is observed, in line with expected results.

[35]Results for 6, 9 and 12 Month Euribor are qualitatively similar and available from the author upon request

The explicative capacity of fluctuations in liquidity reduces from 82.6% in 2007 to 38.1% for the entire period. Regression coefficients are positive, reflecting the sustitivity of cash and bond markets in Europe. This is in contrast with findings in Fontaine and Garcia (2012) where poor sustitivity between bond and cash markets is observed. The relevance of Irish liquidity is in line with the documented behavior of their banking system over the considered period.[36]

Table 3.9.: *Liquidity effects on 2 year IRS excess returns*

	2007-2011	2007	2007-2008	2007-2009	2007-2010
AUSTRIA	-0.175***	0.452***		-0.289***	-0.347***
	(0.000)	(0.000)		(0.000)	(0.000)
BELGIUM	0.0648***			0.0568***	0.0690**
	(0.003)			(0.009)	(0.016)
SPAIN	0.101***	-0.281***	0.179**	0.181***	
	(0.001)	(0.000)	(0.019)	(0.000)	
FINLAND	0.142***	0.219*	0.262***	0.256***	
	(0.001)	(0.068)	(0.000)	(0.000)	
GREECE	-0.0458*		0.170**		
	(0.093)		(0.019)		
IRELAND	-0.115**	-0.326***	-0.108**		
	(0.050)	(0.003)	(0.038)		
ITALY	-0.190***		-0.169*		-0.168***
	(0.000)		(0.083)		(0.000)
NETHERLANDS	0.0774**	-0.166**			
	(0.022)	(0.017)			
PORTUGAL	-0.162***	-1.785***	-0.355***	-0.261***	-0.210***
	(0.002)	(0.000)	(0.001)	(0.000)	(0.000)
Adjusted R^2	0.836	0.944	0.820	0.855	0.812

p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Joint variability of Eonia and Euribor rates could be contaminating results through rates correlation. Table 3.9 present the results when considering an alternative excess

[36] Irish banks increased the amount borrowed over the period in the interbank market at a 3 month horizon and used that to concede new mortgages and buy government bonds.

return measure. This is computed as the difference between Euribor 6 month rates and 2 year vs 6 month Euribor IRS rates. IRS rates reflect the fixed payment a bank will receive each year of the duration of the contract against a six month floating payment equal to 6 month Euribor. Hence, its difference with 6 month annualized Euribor rate provides an idea of the risk premium assumed by the bank when providing liquidity in the short run while borrowing in the long run.

Overall, regression results point in the same direction as the ones obtained for Euribor loans. A progressive decay in the relation between bond liquidity and cash markets, as measured by R^2.[37] When analyzing the relation of both variables by country, an asymmetric relation contingent on the category, Core/Peripheral, reveals. While cash and bond markets are substitutes for core countries, this is not the case for peripheral ones. This validates the perception of core banking systems as cash lenders, with peripherals behaving as cash borrowers.

3.5. Conclusion

In this paper I have illustrated the existence of an additional relevant factor to understand the evolution of bond prices. That factor is seen to relate with capital conditions. It is obtained through the incorporation on an affine structure of an exponential term related to the time a bond has been traded in the market (age). The specification of that factor is rationalized, making use of the theoretical relation between bond prices and capital, presented on previous chapter.

The validity of my factor, as a proxy for liquidity, is analyzed. I find a negative relation between future repo rates excess returns and that factor. This is consistent with the relation that would exist between liquidity and bond funding conditions. As bond liquidity risk reduces, cash lenders would be more prone to accept bonds as collateral on their funding operations. Hence, the excess of return required for those transactions should reduce.

[37] The difference between Euribor and Eonia rates represent the premia to long term lending operations. The difference between Euribor and 2 year IRS rates represent the premia of short term lending operations. Therefore, regresion coefficients of the liquidity factor should exhibit opposite signs

Previous chapter model, suggests the existence of linkages between contemporaneous bond market prices and previous period capital, due to the aggregate nature of that. The time a bond has been quoted in the market should, then, be understood as an instrumental variable of wealth accumulation during the period and, hence, of liquidity. Evidence on the relation between liquidity conditions and bank capital formation is found. Future market-to-book value is negatively related with actual liquidity conditions, and hence positively related with capital accumulation (book value). This relation is only found relevant for countries suffering banking crises.

My results point towards the existence of two liquidity differentiated bond markets within the euro-zone. The first group is composed by core countries and the second by peripherals. A further characterization in terms of bond market size is, also, found. Flight to liquidity between bigger and smaller countries, within each category, exists. Liquidity changes are first identified on smaller countries, with contagion to bigger countries, subsequently taking place.

The relation between bond and cash markets is, also, affected by this differentiated behavior. Sustitivity between bond and cash markets for core countries exists, while this is not the case for peripherals. This points towards the existence of a differentiated borrowing behavior. Core countries behave as cash lenders, using their bond holdings as collateral on ECB refinancing operations, while peripherals behave as cash borrowers.

However, a paulatine lost of representativity of interbank cash markets, over the considered period is found. While at the beginning of the crisis, fluctuations in bond liquidity conditions explain up to an 80% of the risk premium observed in the interbank market, by the end of the sample period that capacity has reduced by a half. This result reinforces my perception on the existence of linkages between the evolution of liquidity, bank capital, and the quality of that.

My results highlight the existence of a contagion channel, in the short term, between CDS market and the liquidity of bonds. Even though, in the long term CDS spreads are not related with liquidity concerns and, hence, should be understood as valid measures of default probabilities, in the short term liquidity squeezes could lead to an increase in the perception of risk of underlying obligors. Hence the widespread use of CDS spreads as sufficient measures of the default perception, at least at short term horizons is challenged.

Moreover, my results also suggest that a substantial part of the short term evolution of bond yield risk premium is driven by changes in liquidity. A similar result is found in Beber, Brandt, and Kavajecz (2009). When this results are considered in conjunction with those characterizing the relation of liquidity changes and CDS spread formation, government recapitalization rules based on yield/credit spreads are questioned. If the raise on those measures comes from an adverse evolution of liquidity (that is of bank capital) tax payers should not be made responsible and direct bank recapitalization/resolution mechanisms should be put in place. This appears to have been, also, the conclusion of European authorities and has led to the design of new banking regulation.

A. Expression for the drift term, $a(m)$, of the affine model

Expression for $a(m)$: In Christensen, Diebold, and Rudebusch (2009) it is shown that the expression for the time to maturity dependent constant of the affine term structure, $a(m)$, is given by:

$$
\begin{aligned}
a(m) = \frac{(\sigma_1 m)^2}{6} + \sigma_2^2 \left[\frac{1}{2\lambda^2} - \frac{1 - e^{-\lambda m}}{m\lambda^3} + \frac{1 - e^{-2\lambda m}}{4m\lambda^3} \right] + \\
+ \sigma_3^2 \left[\frac{e^{-\lambda m}}{\lambda^2} - \frac{m e^{-2\lambda m}}{4\lambda} - \frac{3e^{-2\lambda m}}{4\lambda^2} + \frac{5\left(1 - e^{-2\lambda m}\right)}{8m\lambda^3} - \frac{2\left(1 - e^{-\lambda m}\right)}{m\lambda^3} \right]
\end{aligned}
$$

where m is the time to maturity in years. □

B. Tables

Table A.1.: *Spill-over effects of the liquidity factor, 2 month horizon*

	AT	NL	FI	FR	BE	IE	ES	GR	IT	PT
L2.AT	0.965***	0.0500***	-0.0430***	-0.0843***		-0.0173***	-0.162***	0.295***		-0.0604***
	(0.000)	(0.000)	(0.001)	(0.000)		(0.005)	(0.000)	(0.000)		(0.000)
L2.FI	0.0763***	-0.0559***	0.850***		0.0454***	0.0132***	0.0343***	0.132***	0.0158***	-0.0397***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.001)	(0.000)	(0.005)	(0.000)
L2.FR	-0.0608***	0.0601***	0.0280***	0.815***		-0.0737***	0.0707***	-0.0276**	-0.0326***	-0.0318***
	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.025)	(0.000)	(0.000)
L2.BE	-0.0295***	-0.0821***	-0.0446***	0.0699***	0.835***	0.00991**	-0.0191***	0.0992***	0.0932***	0.00984**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.019)	(0.000)	(0.000)	(0.000)	(0.036)
L2.IE	0.0201**		-0.0471***	0.0631***	-0.0413***	0.974***	0.296***	-0.177***	-0.0919***	
	(0.033)		(0.000)	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
L2.ES	0.0240***	0.0904***	-0.0359***		0.0833***	-0.0377***	0.771***	0.0922***	0.0531***	-0.0451***
	(0.001)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L2.GR	-0.0295***	0.0626***		-0.107***		0.00628***	-0.0815***	0.701***	-0.0692***	
	(0.000)	(0.000)		(0.000)		(0.009)	(0.000)	(0.000)	(0.000)	
L2.IT	-0.0698***	0.108***	0.0883***	-0.155***	-0.0897***	-0.0129***		-0.134***	0.836***	-0.0182***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)		(0.000)	(0.000)	(0.005)
L2.PT	-0.0197***	-0.0943***	0.0580***		-0.0527***	0.0367***	-0.231***		0.0457***	1.005***
	(0.008)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)		(0.001)	(0.000)
L2.NL		0.898***	0.0468***	0.0585***	0.0422***		-0.161***		-0.0233***	
		(0.000)	(0.001)	(0.000)	(0.000)		(0.000)		(0.010)	
Observations	2440	2440	2800	2440	2800	2440	2440	2420	2440	2800

p-values in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.2.: *Spill-over effects of the liquidity factor, 3 month horizon*

	AT	NL	FI	FR	BE	IE	ES	GR	IT	PT
L4.AT	0.913***	0.0941***	-0.106***	-0.127***			-0.299***	0.511***		-0.112***
	(0.000)	(0.000)	(0.000)	(0.000)			(0.000)	(0.000)		(0.000)
L4.FI	0.142***	-0.137***	0.689***		0.115***	0.0228***	0.0556***	0.185***		-0.0771***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.002)	(0.000)	(0.000)		(0.000)
L4.FR	-0.108***	0.0915***	0.0442***	0.735***		-0.137***	0.0796***		-0.0555***	-0.0520***
	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)
L4.BE	-0.0709***	-0.116***	-0.0654***	0.0626***	0.692***	0.0182***		0.130***	0.163***	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.010)		(0.000)	(0.000)	
L4.IE	0.0534***		-0.0788***	0.146***	-0.0592***	0.898***	0.526***	-0.292***	-0.167***	
	(0.009)		(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
L4.ES	0.0413***	0.171***	-0.0970***		0.168***	-0.0580***	0.586***	0.118***	0.0798***	-0.0839***
	(0.001)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L4.GR	-0.0399***	0.0936***		-0.151***		0.0134**	-0.145***	0.454***	-0.0882***	
	(0.000)	(0.000)		(0.000)		(0.043)	(0.000)	(0.000)	(0.000)	
L4.IT	-0.115***	0.201***	0.180***	-0.196***	-0.189***	-0.0257***		-0.195***	0.741***	-0.0358***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.006)
L4.PT	-0.0383**	-0.233***	0.117***		-0.107***	0.0955***	-0.393***		0.0568***	0.982***
	(0.014)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)		(0.005)	(0.000)
L4.NL		0.731***	0.0876***	0.102***	0.0846***		-0.266***		-0.0736***	
		(0.000)	(0.001)	(0.000)	(0.000)		(0.000)		(0.000)	
Observations	2438	2438	2778	2438	2778	2438	2438	2398	2438	2778

p-values in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.3.: *Descriptive Statistics of Bond Prices Data by Country*

COUNTRY	AT	BE	CH	DE	ES	FI	FR	GR	IE	IT	NE	PT	TOTAL
# OF REFS	4,196	20,453	5,807	11,088	4,752	3,000	12,337	11,019	3,482	10,368	5,108	3,846	95,456
MEAN	16	78	22	42	18	11	47	42	13	40	20	15	366
ST DEV	2.80	1.69	1.15	10.69	1.95	2.25	1.14	4.77	1.32	9.84	0.68	0.65	21.53
MAX	19	83	24	58	22	15	50	53	16	54	23	16	400
MIN	11	73	20	26	15	9	45	36	11	25	18	14	336

Table A.4.: *Statistics of Time Series Data*

STATISTIC	VSTOXX	STOXX 600 BK INDEX	EURIBOR 3M	EURIBOR 6M	EURIBOR 9M	EURIBOR 12M	IRS 1Y	IRS 2Y	IRS 5Y	IRS 10Y
# OF OBS	2822	2822	2822	2822	2822	2822	2822	2822	2822	2822
MEAN	28.5008	1.0527	2.4854	2.6610	2.7656	2.8623	2.7101	2.8087	3.2782	3.7656
ST DEV	11.2292	0.5739	1.6922	1.6081	1.5643	1.5285	1.5402	1.3600	0.9894	0.7272
MAX	81.0300	2.3500	5.3810	5.4310	5.4630	5.4930	5.4380	5.4410	5.1600	5.0700
MIN	13.4500	0.3500	0.6350	0.9450	1.0850	1.2140	1.0760	1.2410	1.7280	2.3740

Table A.5.: *Descriptive Statistics by Country*

		CDS SPRD	1Y YD	2Y YD	3Y YD	4Y YD	5Y YD	6Y YD	7Y YD	10Y YD	LEND. FEE
	# OF OBS	179	260	260	260	260	260	260	260	260	165
	MEAN	0.9372	2.1514	2.4602	2.7342	2.9754	3.1853	3.3659	3.5188	3.8293	0.3800
AT	ST DEV	0.4655	1.5156	1.2930	1.1111	0.9626	0.8414	0.7434	0.6659	0.5440	0.3289
	MAX	2.6500	4.8347	4.7695	4.8125	4.8327	4.8329	4.8220	4.8158	4.8785	2.5552
	MIN	0.1100	0.0174	0.6450	1.1287	1.3914	1.6367	1.8784	2.1061	2.5783	-0.2043
	# OF OBS	211	260	260	260	260	260	260	260	260	260
	MEAN	1.0281	2.3610	2.6985	2.9870	3.2321	3.4388	3.6127	3.7589	4.0847	0.4372
BE	ST DEV	0.8137	1.3739	1.1794	1.0212	0.8848	0.7629	0.6544	0.5618	0.4260	0.5058
	MAX	3.9878	4.7725	5.1106	5.4829	5.6715	5.7280	5.7035	5.6495	5.8233	2.9997
	MIN	0.1150	0.5561	0.8934	1.2201	1.5497	1.8746	2.1803	2.4524	2.9224	-0.5241
	# OF OBS	95	260	260	260	260	260	260	260	260	258
	MEAN	0.4811	1.0938	1.2131	1.3482	1.4932	1.6419	1.7885	1.9269	2.2326	1.0473
CH	ST DEV	0.1258	1.0258	0.9824	0.9347	0.8816	0.8251	0.7693	0.7185	0.6304	1.1154
	MAX	0.7533	3.0120	3.0376	3.0656	3.0958	3.1498	3.1971	3.2324	3.3277	8.2684
	MIN	0.2922	-0.1452	-0.0006	0.0667	0.1125	0.2095	0.3437	0.4949	0.9173	0.1771
	# OF OBS	179	260	260	260	260	260	260	260	260	244
	MEAN	1.8579	2.6782	3.0697	3.3845	3.6353	3.8350	3.9965	4.1327	4.5180	-0.0733
ES	ST DEV	1.1175	1.4465	1.1363	0.9310	0.7911	0.6948	0.6333	0.5989	0.5528	0.7425
	MAX	4.8168	6.1229	6.1315	6.1472	6.1733	6.2132	6.2702	6.3476	6.7360	1.1313
	MIN	0.3600	-0.0565	1.1838	1.8696	2.3589	2.7293	2.9917	3.2248	3.8892	-2.6730
	# OF OBS	197	260	260	260	260	260	260	260	260	206
	MEAN	0.3521	2.1046	2.3427	2.5751	2.7968	3.0029	3.1885	3.3487	3.6267	0.3362
FI	ST DEV	0.1939	1.5298	1.3743	1.2349	1.1037	0.9801	0.8683	0.7748	0.6824	0.4348
	MAX	0.9400	4.6870	4.8211	4.8853	4.8989	4.8808	4.8502	4.8261	4.9843	2.7000
	MIN	0.0925	0.3377	0.5342	0.8125	1.1387	1.4077	1.6640	1.8990	2.1416	-0.7819

FR	# OF OBS	179	260	260	260	260	260	260	260	260	260
	MEAN	0.7265	2.1222	2.3843	2.6228	2.8388	3.0335	3.2079	3.3633	3.7258	0.3044
	ST DEV	0.4938	1.5088	1.3280	1.1693	1.0315	0.9134	0.8133	0.7298	0.5607	0.3044
	MAX	2.4527	4.7265	4.7377	4.7491	4.7608	4.7753	4.7923	4.8099	4.8644	2.0520
	MIN	0.1100	0.2476	0.6754	1.0634	1.3436	1.5824	1.7968	1.9881	2.4364	-0.3744
GR	# OF OBS	173	222	222	222	222	222	222	222	222	188
	MEAN	3.6225	4.7496	5.4825	5.9276	6.1491	6.2116	6.1793	6.1167	6.3902	0.4544
	ST DEV	3.4982	3.1603	3.4277	3.5933	3.5809	3.4236	3.1869	2.9381	2.7627	1.3683
	MAX	10.9021	16.8540	17.2828	17.2503	16.8511	16.1793	15.3293	14.3956	14.5468	13.7867
	MIN	0.1690	0.9208	1.7877	2.4080	2.8982	3.2823	3.5672	3.7540	4.1297	-1.9670
IE	# OF OBS	199	260	260	260	260	260	260	260	260	247
	MEAN	3.3374	3.8600	4.4340	4.8655	5.1756	5.3851	5.5150	5.5863	5.6579	1.0896
	ST DEV	2.7275	2.2621	2.5049	2.6714	2.7283	2.6818	2.5531	2.3698	1.7883	3.2808
	MAX	11.7613	14.5361	17.0435	18.3760	18.7351	18.3225	17.3396	15.9881	11.7372	24.9444
	MIN	0.1825	0.9061	1.6419	2.2459	2.6944	3.0931	3.4411	3.7350	4.0718	-2.1669
IT	# OF OBS	211	260	260	260	260	260	260	260	260	260
	MEAN	1.5568	2.8736	3.1406	3.3859	3.6104	3.8150	4.0006	4.1683	4.5728	0.1732
	ST DEV	1.2121	1.3626	1.2073	1.0745	0.9633	0.8724	0.8002	0.7446	0.6521	0.3892
	MAX	5.5434	7.5429	7.5566	7.5746	7.5961	7.6204	7.6466	7.6741	7.7563	2.2707
	MIN	0.1650	0.9414	1.4209	1.8499	2.2316	2.5764	2.8863	3.1286	3.6937	-1.2844
NL	# OF OBS	194	260	260	260	260	260	260	260	260	260
	MEAN	0.4944	2.1010	2.3496	2.5814	2.7961	2.9929	3.1713	3.3306	3.6889	0.3913
	ST DEV	0.2953	1.5486	1.3645	1.2115	1.0797	0.9647	0.8658	0.7833	0.6575	0.4742
	MAX	1.3384	4.6644	4.6362	4.6950	4.7287	4.7442	4.7608	4.8103	4.8164	3.2119
	MIN	0.0625	0.1201	0.4681	0.7965	1.1023	1.3662	1.5941	1.8042	2.2166	-0.2554
PT	# OF OBS	211	260	260	260	260	260	260	260	260	260
	MEAN	3.1252	4.7141	5.0055	5.2354	5.4112	5.5406	5.6308	5.6896	5.7514	0.4888
	ST DEV	3.5719	4.5518	4.2259	3.9966	3.8045	3.6201	3.4320	3.2361	2.5708	0.8039
	MAX	12.3223	21.9345	19.5967	18.3553	18.3822	17.8803	17.0226	16.2202	14.5631	4.1383
	MIN	0.1635	0.8329	1.4395	1.9568	2.4012	2.7475	3.0288	3.2611	3.7732	-0.6700

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